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INTERNATIONAL CO-OPERATION IN SCIENCE AND TECHNOLOGY

PERHAPS the most outstanding feature of the first International Conference on the Peaceful Uses of Nuclear Energy held in August 1955 was the way in which it was regarded by scientists as re-establishing the old spirit of scientific co-operation, and promoting in this field both the contact between scientists which had largely been interrupted and the conditions for the free exchange of ideas upon which scientific advance depends. There has since been a notable increase in the release of information in this field which had been classified as secret, and the establishment of the Eurochemie company and the European Nuclear Energy Agency would scarcely have been possible unless scientists and technologists were relatively free to co-operate and discuss common problems. Moreover, it has become even clearer in the past three years that, in nuclear science, equipment is so costly that only by a co-operative effort can we expect to keep the units in economic use or even provide the resources to construct them.

Nevertheless, in his opening address to the second International Conference on the Peaceful Uses of Atomic Energy on September 1, Prof. Francis Perrin, who began with a reference to the value of co-operation and the stimulus to scientific development and to the improvement of education generally and especially to scientific and technical training which was likely to be the first gain to any country from nuclear energy, found it necessary to stress the foolishness of continued secrecy. These international conferences, he said, render great service to the cause of peace by reducing the barriers of secrecy in vast areas of scientific and technological activity. They gave governments a favourable opportunity to declassify areas of knowledge and thus reveal secrets which are found to be largely identical, though the discoveries have been made independently.

This demonstration of the wastefulness of secrecy in itself leads to the removal of restrictions on further areas of knowledge. The wide interest taken generally in this strictly scientific and technical conference, however, offered Prof. Perrin an unrivalled opportunity, which he did well to use, to explain why it is so important to remove so far as possible the secrecy which, since the Second World War, veiled scientific activities in which exchanges of ideas and publications were formerly free. His exposition of the harm done by secrecy, the loss it causes to humanity, and its limited advantages to those who impose it and the serious drawbacks that result even for them, was addressed not primarily to the scientist but to the politician, and to the world generally, which is so profoundly interested in the industrial uses of nuclear energy.

The most obvious disadvantage of secrecy is its adverse effect on the progress of the sciences where it is introduced, by limiting the exchange of ideas and knowledge to more or less restricted groups, and by requiring each group thus isolated to carry out or repeat all the exploratory and methodological work which could have been shared. This is particularly serious for the weakest groups, as they are condemned to an increasing delay which may eventually render their work sterile; but it also adversely affects the strongest groups, since they are deprived of results that could have been obtained by other less well-endowed groups if they had been kept well-informed and so could have worked along neglected directions rich in possibilities. Even in a situation of abundant scientific and technical man-power, there can never be enough available to explore all the attractive and potential avenues. In the situation of scarcity which characterizes the whole Western world at least, progress in nuclear energy and in any other field depends on our ability to make the fullest possible use of all available knowledge and the elimination so far as possible of all overlapping and duplication of effort. The recent conference should have reminded Great Britain in particular of the importance of concentrating her resources on a few carefully chosen projects rather than diffusing them over too wide a field.

No less important, and particularly in reference to the more creative work at the frontiers of an advancing science or technology, is the harm which secrecy does to all groups by excluding the salutary criticism which often comes most effectively from independent groups. Nor is it simply that such criticism can prevent costly mistakes. It is often a stimulus to new ideas, particularly at the meeting place of different disciplines. Finally, as Prof. Perrin notes, the existence of secrecy may deter the most valuable and creative minds from entering such fields of research.

This retarding of scientific progress he regards as only the least of the evils of secrecy in important sectors of research. It also prevents science from acting as the link between men that its universal character enables it to provide: on the contrary, it engenders distrust and poisons human relations in the sphere where they best allow an intermingling of civilizations. Even in the sphere of Anglo-American relations, misunderstanding and friction have been caused by secrecy, and co-operation has been seriously hindered.

Prof. Perrin may tend to over-estimate the contribution which science can make to international co-operation when he characterizes mutual distrust as the most harmful effect of secrecy. Nevertheless, the activities of the international scientific unions and of the special agencies of the League of Nations between the two World Wars showed that it can exert an important influence; and he is undoubtedly right in referring also to the influence in the formation of character of the practice of the disciplines of scientific research and of teaching the sciences, or

even of a severe scientific upbringing. Science requires a perfect sincerity with oneself as well as with others, an objective pursuit of truth which goes beyond its own field and penetrates the nexus of relationships between men. It demands a discipline of thought and expression that rejects the empty emotional bombast that is particularly apt to put peoples against each other.

Now, as Prof. Perrin rightly observed, to enclose important fields of research and scientific work, by preventing the men engaged in them from communicating freely with those studying the same problems in other countries, is to lose all the benefit of the mutual understanding and fraternal feeling in the same task that comes with normal relations between scientists. It is a breach, in a limited but important field, of fundamental human freedoms and rights: freedom of expression and information—the right, even the duty, to impart instruction—the right of all to learn and to know all that has been discovered about the mysteries of Nature. We should not exaggerate the importance of this factor—and Prof. Perrin recognizes that we should not expect scientists to differ morally from other men—but when all allowance is made for the effect of that resistance to knowledge which Dr. J. Trenaman stressed in a recent suggestive address to the Library Association, we can ill afford to neglect any means of strengthening co-operation and understanding between the nations. Even from the negative aspect of removing possible causes of friction or distrust, the restoration of normal relations between men working in the various secret fields of research on the use of nuclear energy is a notable contribution to the strengthening of peace.

The importance of this contribution, in Prof. Perrin's view, depends less on the numbers of these men and their part in the development of major national programmes than on their predominant position in the scientists' awareness of their special responsibility to society. Regarding the bringing of men together as the most valuable result of the Conference, he regretted that the Conference is still not fully representative, and that some great peoples are still absent from these exchanges of ideas and this rebuilding of the international scientific community. Until such conferences are fully representative, their contribution to international goodwill and understanding, whatever their intrinsic merits, will be incomplete.

While, therefore, it is appropriate that, on the scientific and technical plane, due thought should be given to the most appropriate and economic intervals at which such conferences should be held, having regard to the considerable interruption of normal scientific and technical effort which they inevitably involve, this other aspect should be kept in mind. No effort should be spared which promises to make such conferences fully representative of the nations. Put at the very lowest level, they help the nations to live peacefully together in this technological age by emphasizing the positive contribution of nuclear energy to human welfare as against the destructive power of nuclear weapons. To the extent that the area of knowledge and understanding of nuclear energy is widened, an inroad is made into the fear and distrust that hinder international co-operation and are a continuing threat to world peace. For its indirect contribution to that end, no less than for its bearing on the advancement of science and technology and on the most effective use of our own limited resources of both equipment or scientific and technical man-power, scientists and technologists in Great Britain should make sure that the points made by Prof. Perrin regarding the foolishness of secrecy are fully apprehended by the Government. Security considerations must not be allowed to hinder the exchange of scientific and technological knowledge beyond the severest limits that independent—and not departmental or subjective—judgment approves; and this applies not only in Great Britain but also in every other country of the world which is striving for an era of universal peace and prosperity.

SOCIAL CONDITIONS IN ENGLAND AND WALES

A Survey of Social Conditions in England and Wales as Illustrated by Statistics

By A. M. Carr-Saunders, D. Caradog Jones and C. A. Moser. Pp. xxi+302. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 25*s*. net.

IN 1927 Sir Alexander Carr-Saunders and Mr. Caradog Jones published the first edition of their "Survey of the Social Structure of England and Wales, as illustrated by Statistics". A second edition, which incorporated figures from the 1931 census appeared ten years later, and the present volume, which has been entirely rewritten, with Mr. C. A. Moser joining the original team of authors, brings the work up to date, using the mass of material that has appeared since the War.

The authors write as social statisticians rather than as sociologists. Their aim is to provide a factual background, to distil the large volume of statistical information that is now available, so that a clear picture emerges for those who are unfamiliar with the pitfalls besetting the interpretation of official data. They aim at avoiding explicit value judgments, so far as possible, and content themselves with description, rather than comment.

The third edition keeps up the high standard set by the two previous ones; indeed, in arrangement and coverage it has been improved in many ways. Full use is made of the large amount of new information that has been collected as a result of war and post-war policy. The authors' task of selection and summarizing must have been much more difficult than twenty years ago, though the value of their labours is correspondingly increased. For the student of social conditions the book will be an indispensable starting point.

It is interesting to compare the changes that have been introduced in the present edition. There are chapters on nutrition, health, the use of leisure and religion which did not appear in the 1937 edition, though some of these topics will have been treated elsewhere in that volume. The section on personal expenditure has been greatly expanded, using the data collected by the Central Statistical Office, and

in the Ministry of Labour's household expenditure inquiry. On the other hand, the chapters on voluntary provision against misfortune, voluntary transfer from rich to poor, poverty, and the inborn qualities of the population have been omitted in the 1958 edition. A comprehensive chapter on social security has been substituted. The sections on education and on crime have been completely recast. The result is a clear picture of social conditions in Britain to-day, in so far as statistics are available to illustrate them. The qualification is important. In spite of the considerable improvement that has taken place in the provision of statistical data, there are still gaps, particularly in social statistics. Thus, the authors comment that national statistics dealing with the distribution of personal property "hardly exist" and figures on personal incomes are "sparse enough". They might have added that income which is liable to and declared for income tax purposes is not always the same as spendable resources. Moreover, most of these data are global in character and it is not possible, as a general rule, to trace the distribution of incomes in particular social or economic groups.

However, the general picture that emerges is that of a society in which inequalities have been reduced, in some cases not inconsiderably, during the past twenty years. There is, however, no ground for complacency on this account. Thus, in the chapter on nutrition it is stated without qualification that the diet of larger households is still inadequate and that some of the deficiencies are not negligible. As regards the ownership of property, the authors quote the Oxford Survey's figure which shows that one-third of all households have no liquid assets at all, a far cry from the picture of a 'property-owning democracy'.

There is one surprising omission: no use is made of the census of distribution to show the structure of wholesale and retail distribution; the authors probably regarded this as part of the 'economic' rather than the 'social' conditions of England and Wales. There is one error which ought to be pointed out in order to restore peace of mind to happily married readers of the book. The statement on p. 8 that "the longer a marriage has lasted, the greater the chance of divorce" is not correct. The risk of divorce, in fact, decreases after a marriage has lasted for about ten years.

E. GREBENIK

COLORIMETRIC ANALYSIS

Colorimetric Determination of Nonmetals

Edited by David F. Boltz. (Chemical Analysis: a Series of Monographs on Analytical Chemistry and Its Applications, Vol. 8.) Pp. xii+372. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1958.) 8.50 dollars.

THIS book, Vol. 8, of a series of monographs, may be regarded as supplementary to Prof. Sandell's "Colorimetric Determination of Traces of Metals" (Vol. 3 of the series).

Chapter 1 of the present volume deals quite adequately in twenty-eight pages with principles and practices in colorimetric analysis. Subsequent chapters, written by specialist authors, deal with the individual elements, each chapter being subdivided into sections concerning separations, methods of determination and applications.

The methods described for the determination of phosphorus are those based on the development of molybdenum blue and on the formation of molybdovanadophosphoric acid and molybdophosphoric acid, due attention being paid to possible interferences. Applications dealt with are the determination of phosphate in industrial waters and of phosphorus in steel, serum, and copper base alloys (26 references).

The chapter on silicon deals mainly with applications of the molybdosilicic acid method and the heteropoly blue complex method. Methods for the determination of silicon in various alloys, steel, water, biological materials, foods and agricultural material are described (31 references).

There follows a very comprehensive chapter of 85 pages on nitrogen. A section dealing with Kjeldahl digestion provides a useful summary, including a discussion of the effectiveness of some catalysts, and has applications obviously not limited to colorimetric determinations. The recovery of ammonia by distillation, aeration, and microdiffusion, and all aspects of the Nessler method, are dealt with in considerable detail. Other methods are discussed. Practical details are given for the determination of various forms of nitrogen in water, sewage, biological materials, soil, plants, steel, zirconium and petroleum products, and the sections concerned with nitrite and nitrate include descriptions of methods for the determination of oxides of nitrogen in air (203 references).

The chapter on chlorine is concerned with *o*-tolidine, methyl orange and König reaction methods for free chlorine, nephelometric, silver chromate, silver phosphate and mercuric nitrate methods for chloride, benzidine and nephelometric methods for chlorate, a benzidine method for hypochlorite, and a methylene blue method for perchlorate (37 references).

For the determination of bromine, the colorimetric methods described are preceded by volatilization as free bromine or cyanogen bromide or by oxidation to bromate. The colorimetry is based on König's reaction or on reactions with methyl orange, phenol red, rosaniline, fluorescein or gold chloride. Specific applications described are concerned with the determination of bromine in flour, blood, sea water and brine (34 references).

Preliminary separations dealt with in the chapter on iodine are distillation, extraction by solvents such as toluene, and microdiffusion. Organic matter is destroyed by alkaline ashing or by treatment with acid oxidants, under conditions which are stated to cause no loss of iodine. For the actual determinations, the methods given pride of place and discussed in considerable detail are based on the catalytic effect of iodide on the reduction of cerium-IV by arsenic-III. Probably the average chemist would prefer the more direct colorimetric methods, such as starch–iodine methods (which are also described). Methods based on the extraction of iodide from saturated potassium carbonate solutions and on the oxidation of iodide to iodate by bromine water are not described (127 references).

The chapter on fluorine commences with a discussion of the correct design of apparatus for the Willard and Winter distillation, of the distillation procedure, and of factors that affect quantitative recovery. Other methods of separation receive brief mention. Of all the methods of determination considered, including the zirconium and thorium alizarin methods, a zirconium eriochrome cyanine *R* method is considered most generally suited for photometric analysis. Methods

are given for the determination of fluorine in urine, teeth and bones, blood and soft tissues, agricultural samples and water (38 references).

The earlier pages of the chapter on sulphur contain notes on a large number of published methods for the separation and determination of inorganic and organic sulphur. Among methods which receive some detailed consideration are the methylene blue method based on the reaction of sulphide with *p*-aminodimethylaniline in the presence of ferric chloride, and the barium sulphate turbidimetric method. Procedures described in detail include determinations of hydrogen sulphide in gases, of free sulphur in air and in hydrocarbons, of sulphate by benzidine precipitation and diazotization, of sulphur in plants, wool and soils, of sulphides in water and alkalis, and of aliphatic sulphides in hydrocarbons by ultra-violet absorption after reaction with iodine (132 references).

A brief summary of the general chemistry of tellurium and selenium precedes the sections on separations and methods. Following a review, comprising notes on published work, the absorptiometric methods described are based on the formation of iodotellurite, of addition compounds with sulphuric acid, of a compound with diaminobenzidine, and of the tellurium thiourea complex. A colorimetric iodine method for selenium is included. Procedures are given for the determination of selenium in natural waters, copper, steel and arsenic, and of tellurium in lead and copper (46 references).

The chapter on boron commences with notes on precautions, such as avoidance of contamination and loss. Separations are based on distillation as methyl borate, preferably in the cyclic apparatus illustrated. Reactions with quinalizarin, carminic acid, dianthramide or curcumin are used for the actual determinations. Procedures for the determination of boron in steel and alloy steels are given (22 references).

The book contains much very useful information: in general, the treatment is thorough and the choice of methods good.

C. O. Harvey

THE BILE SOLID

Cholesterol

Chemistry, Biochemistry, and Pathology. Edited by Robert P. Cook. Pp. xii + 542. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 15 dollars.

DR. R. P. COOK must have wondered whether a book of this title could be usefully compiled. He need not have worried: he and his team have done well. The work he has edited is a comprehensive survey of most important work (to the end of 1957) on cholesterol; it includes much material on other sterols and more than a little on steroids in general.

A short historical introduction, appropriately written by Henrik Dam, is followed by a thorough, if condensed, chemical survey by Peter Bladon. This includes sections on nomenclature, on physicochemical measurements on steroids, on digitonide and other complex formation and on colour reactions. There are tables of natural sterols, and of physical constants (melting points, optical rotations and ultra-violet spectra) of cholesterol derivatives.

R. P. Cook and J. B. M. Rattray then give a chapter on methods of isolation and estimation of sterols; R. P. Cook describes their distribution in organisms and plant and animal tissues. G. S. Boyd and M. F. Oliver discuss the physiology of blood cholesterol and of lipoproteins in man and other species. R. G. Gould thoroughly reviews our knowledge of sterol biosynthesis, and O. Hechter the conversion of cholesterol to steroid hormones. Geoffrey Bourne contributes a thoughtful and provocative essay on the histological demonstration of cholesterol and on its possible functions in cells. Metabolism in the normal animal is dealt with by R. G. Gould and R. P. Cook, and David Adlersberg and Harry Sobotka discuss pathology. The important and highly topical subject of treatment of disorders of cholesterol metabolism is briefly reviewed by I. H. Page. W. Bergmann contributes a chapter on evolution and sterol distribution, Marjorie Horning discusses sterol requirements of insects and protozoa, and Thressa Stadtman writes about microbial metabolism of steroids.

The book ends with R. P. Cook's account of metabolic relationships between cholesterol and other lipids, and there is an appendix on practical methods of extraction, purification and estimation of sterols and lipoproteins.

The book is thoroughly documented throughout, and it has an adequate index. Its format and illustrations are excellent.

More than all this, it is, for the most part, well and clearly written. Dr. Cook has clearly been a tactful and liberal editor; moreover, he and his collaborators have somehow conveyed a sense of history and of the broad sweep of biochemical advance into a work that might easily have been a dry and dull collection of data.

All interested in its subject-matter will want to have and, having, will want to read this admirable volume.

G. A. D. Haslewood

STABILITY OF NON-LINEAR SYSTEMS

Differential Equations

Geometric Theory. By Solomon Lefschetz. (Pure and Applied Mathematics: a Series of Texts and Monographs, Vol. 6.) Pp. x + 264. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.) 9.50 dollars.

A STANDARD set of differential equations can be taken in the form:

$$dx/dt = X(x,t)$$

where x,X are n-dimensional vectors, t can be thought of as the time, and a solution $x(t)$ is a curve, or trajectory, in the n-space. This formulation shows the need for some matrix technique and some knowledge of simple topological concepts. The important idea of stability then appears in the statement that a trajectory from a given initial point is stable if, roughly speaking, another trajectory starting from a neighbouring initial point nowhere departs substantially from the former.

After introductory chapters on existence theorems and linear systems, Lefschetz defines various types

of stability and examines them in detail for certain important forms of the function $X(x,t)$ such as $Px + q$, where P is a matrix which is either constant or a function of t only, and q is a vector, depending on x and t, which is, in some sense or other, small compared with x. If P is a constant matrix, and q is ignored to get a first approximation, the set of equations is a linear set with constant coefficients, and we may hope that the solution of this simple set will indicate the dominant stability features of the more general set. Much of the content of this section stems from Liapunov's classical monograph on the general problem of stability (1892), but Lefschetz brings the development right up to date by collecting all the salient points from recent research work.

In the latter half of the book, the n-space is specialized to two dimensions. When X is independent of t the equations are said to be autonomous, and in Cartesian form are:

$$dx/dt = f(x,y), \quad dy/dt = g(x,y)$$

The trajectories, which in the autonomous case are called paths by Lefschetz, are studied in considerable detail and much geometrical information about them is obtained, for various special forms of f and g. Then second-order non-linear equations, including the famous van der Pol equation for triode oscillations, are discussed with emphasis on the phase-plane representations: they are reduced to a pair of first-order equations, which may be autonomous, or, as in the case of the Cartwright–Littlewood equation, may contain a function of t on the right-hand side. Finally, there is a chapter on oscillations in a quasi-harmonic system, differing from the simple harmonic equation by a small, variable, perturbation term: Poincaré's perturbation method, and the time-averaging method originated by van der Pol, are described.

Lefschetz's exposition is, as always, vivid and stimulating, and does not demand a great deal of specialized equipment; although some previous acquaintance with matrix notation and the idea of a compact space is desirable, the book itself contains an excellent summary of what is wanted on these topics. In the main sections, the reader will find that he is expected to be quick in grasping new ideas, and should allow himself frequent pauses for assimilation. For the young research student wishing to begin work in this wide and important field, the volume will prove invaluable.

T. A. A. Broadbent

STRUCTURE OF ATOMIC NUCLEI

Handbuch der Physik

Herausgegeben von S. Flügge. Band 39: Bau der Atomkerne. Pp. vi+566. (Berlin: Springer-Verlag, 1957.). 125 D.M.

THIS volume comprises chapters on the two-nucleon problem by Prof. Lamek Hulthén (Stockholm), and Prof. Masao Sugawara (Hokkaido); on the three-body problem in nuclear physics by Prof. Mario Verde (Torino); on the distribution of matter and charge within atomic nuclei by Dr. D. L. Hill (Los Alamos); on the nuclear shell-model by Dr. J. P. Elliott, and Dr. A. M. Lane (Harwell); and on models of nuclear structure by Prof. Steven A. Moszkowski (University of California, Los Angeles).

Profs. Hulthén and Sugawara's contribution, in Chapter 2, gives a complete and compact summary of the experimental data on the two-nucleon problem available up to 1956. The treatment of theoretical questions required for the interpretation of the experimental observations is based on static nuclear potentials as derived from the pseudoscalar field theory. The main merit of this review lies in the careful analysis of the observational data (mostly in the low-energy region) in terms of central forces and the effects achieved when a tensor force is introduced. Sections on high-energy scattering and photo-effect and a mathematical appendix (by Prof. Sugawara) conclude an exemplary piece of scientific reporting. Unfortunately, the recent observations of the polarization of p and n on scattering, of importance in resolving ambiguities in the phase-shift analysis, could not be included. The section on three-body problems and that on matter and charge distribution in nuclei complete what one could call the first part of this volume. Dr. Hill's article illustrates in detail how a single property, such as the finite size of the nucleus and its charge distribution, sometimes has observable effects on a great many atomic and nuclear properties.

The experimental physicist who works in a high-voltage laboratory with a cyclotron and studies the unstable elements will certainly find the second part of the volume dealing with nuclear models particularly welcome. The two articles by Elliott and Lane and by Moszkowski contain everything that the research physicist needs for analysing his data in terms of the mechanism which underlies his observation. It also seems that the review of the shell model is complete in so far as theory is concerned, so that all tools for shell model calculations are at the reader's disposal within its 170 pages; to ease readability, much formal mathematics is placed in eleven appendixes. Dr. Moszkowski's survey of nuclear models offers a lucid and most readable exposé of a mainly non-mathematical character. The general approach is nevertheless that of a theoretician, who ably supports his statements with experimental data. The whole is excellently organized, preventing confusion which could easily arise when one looks at Table 1 with its list of sixteen models. I drew considerable courage from this diversity, since we are not likely to run out of problems during the next five years (though we may do so within ten years), unless Brueckner's theory provides a sudden solution.

Of the total 550 pages in this book, 240 are used for the first three contributions and 310 are devoted to nuclear models. All the contributions are written, in English, by theoretical physicists, 42 per cent of the volume being written by authors working in government laboratories in Britain or the United States, though the topics covered are only remotely connected with the immediate interests of these institutions. They reveal a very high standard of scholarship indeed.

This volume should be within easy reach of all workers engaged on research in the fields covered; it would be so, were it not that the price confines it to libraries, where it will mostly be out on loan. The printing, illustrations and accuracy are of the highest order.

E. Bretscher

RECENT DEVELOPMENTS IN NUCLEAR ENGINEERING*

By Sir JOHN COCKCROFT, O.M., K.C.B., C.B.E., F.R.S.

THE second Geneva Conference on the Peaceful Uses of Atomic Energy revealed the progress in nuclear engineering which has been made during the three years since the first conference.

British experience in operating Calder Hall now extends over two years. The total electrical power generation up to September 1958 has been 938 million kWh., representing a full load power factor of 67 per cent on reactor No. 1 and 81 per cent on reactor No. 2. These high load factors have been achieved in spite of the fact that in this prototype design it is necessary to shut down and release the carbon dioxide pressure before a fuel rod can be changed, this operation taking an appreciable time. During the life-time of the first charge of fuel, only three fuel elements out of the ten thousand developed faults, and so far there has only been one fault in the second charge. In the first charge of reactor No. 2 there have been four positively identified faulty fuel elements, and six channels have been discharged for examination because of rather large signals from the faulty fuel element detector equipment. The fault is usually due to a slight leakage developing in the weld of the magnox alloy can. This allows slow penetration of the carbon dioxide coolant, with resulting oxidization and a slow outleakage of fission products. This usually develops rather slowly, so that fuel elements can be changed when convenient over a period of a week or two. We have had one or two incidences of a more rapid development of a leakage due to a defective weld.

Apart from shutdowns due to the necessity to change faulty fuel elements and to change the whole charge at the end of its life, reactors and power units can go on operating for very long periods; indeed, one reactor operated continuously for six months. Maintenance can be carried out on a single cooling circuit or associated electrical equipment by closing off this circuit and reducing power for an hour or so. There is, in fact, little to go wrong in a graphite-moderated reactor except the fuel elements. No automatic control rod circuits are installed in the Calder Hall reactors, but the circuit has proved to be remarkably stable. The temperature of the fuel element stays constant to $\pm$ 1 deg., and there is a similar stability of power-level. In some very large reactors the distribution of power generated in different parts of the reactor can vary slowly over a period of days, due to the accumulation of the fission gas, radioxenon. As a result of this, an increase in power density on one section of the reactor can burn up more xenon and so increase the reactivity, and the opposite effect can occur in another part of the reactor. These very slow spatial oscillations have not so far been observed in Calder Hall.

Initially, with a new charge, the temperature coefficient of reactivity associated with increases of temperature of fuel elements and of moderator is negative and the system is entirely self-stabilizing. As the radiation of the fuel proceeds, the increasing quantity of plutonium fuel modifies the delayed temperature coefficient associated with the moderator temperature, making it increasingly positive; but the prompt coefficient of temperature associated with the fuel-element temperature remains negative. After an irradiation of about 400 MW. days per ton, the moderator temperature coefficient is about $+ 4 \times 10^{-5}$ in K/degree centigrade. It is expected to reach a saturation-level of about 15×10^{-5} with very long irradiation. The overall effect of this limiting value of the temperature coefficient would be that small increases in power-level could be doubled in a time of about two minutes if no movement of control rods were made to correct this. So after a thermal power-level change of 200–201 MW., the level would increase to 202 MW. in two minutes and to 204 MW. in four minutes.

These effects of the positive temperature coefficient occurring over such relatively long periods of time do not require any changes in the normal control of a station, and indeed they are not generally observable to the operator since general small circuit fluctuations require small corrective action to be taken on a similar time-scale. These are examples of the wide range of operational experience we have gained during the past two years. This experience has given us great confidence in this type of power station.

The Shippingport nuclear power station uses a pressurized water reactor to produce 230 MW. of heat, leading to 60 MW. of electricity. This power station went into operation on December 18, 1957, and a brief account of its operational characteristics was given at the recent Geneva Conference on the Peaceful Uses of Atomic Energy. The time taken to get the power station on load from ambient temperature is 8 hr., this being set by thermal stress. The reactor operation has a high negative coefficient of reactivity. On one occasion the condenser vacuum was lost and the turbine shut down automatically. The negative temperature coefficient reduced the reactor output to essentially zero without any movement of control rods, the only effect on the plant being an increase of system pressure from 2,000 to 2,160 lb. sq. in.

The first Russian large-scale nuclear power station came into operation during the period of the Geneva Conference. The power station is to consist of six identical 100-MW. electrical units. The heat source is a graphite-moderated water-cooled reactor, apparently scaled up from the 5-MW. power station reported at the 1955 Geneva Conference. The reactor has pressure tubes of stainless steel to separate the high-pressure coolant from the graphite. The fuel is natural uranium. Steam reaches the turbines at a pressure of 90 lb./sq. in. at 185° C. The power station seems to be a dual-purpose plant. It is the first major contribution to the U.S.S.R. 2,000-MW. programme of nuclear power stations.

None of these three power stations was designed as a commercial nuclear power station. They are either

*Substance of a lecture to the Danish Society of Civil Engineers, delivered on October 6.

prototypes or dual-purpose reactors, and their capital costs per kW. hr. are high.

The second generation of nuclear power stations are very different. They have usually been designed specifically as power stations for electricity authorities. In Britain they include four graphite-moderated carbon dioxide cooled reactor power stations due for completion at dates ranging from 1960 to 1962 with outputs ranging from 275 to 500 MW. for a two-reactor station. In the United States there are under construction two pressurized-water and one boiling-water reactor power stations having outputs ranging from 134 MW. electrical to 275 MW.(e), the latter being boosted by 110 MW. of oil superheating. In addition, a 100-MW.(e) electrical fast reactor is being constructed. All these are due for completion by the end of 1960. The French are building two graphite-moderated carbon dioxide cooled reactor power stations of 63 MW. and 170 MW., respectively, for completion by about the same period. Italy is to build one British type of power station and one station similar to the U.S. Dresden power station, using a boiling-water reactor as heat source. The Russians are building two 420-MW. stations, each using two pressurized-water reactors. They are also building a 400-MW. power station using four graphite-moderated reactors in which the steam is superheated inside the reactor.

The British stations are typified by the Somerset power station, which is to generate 500 MW.(e). Each reactor contains about three times as much uranium as in the Calder Hall reactors. The pressure of the carbon dioxide coolant is 85 per cent higher than Calder Hall. The fuel element surface temperature is 430° C. compared with 408° C. at Calder Hall. The heat-transfer surfaces of the fuel elements have also been improved over Calder Hall. The effect of this increased pressure, increased temperature and improved surface has been to increase the average rating from the 1·4 MW./ton in Calder Hall, to 2·6 MW./ton at Hinckley Point. This has resulted in reactor capital costs being reduced by about 20 per cent from the first of the four power stations, and is now of the order of £110 per kilowatt exclusive of costs of fuel and site preparation. For the purpose of economic forecast, the fuel elements have been assumed to achieve an average heat output of 3,000 MW. per ton. Reactivity changes due to substitution of plutonium for uranium-235 and accumulation of fission products will not limit the life of fuel elements before appreciably longer burnups. The limit will probably be set at first by metallurgical imperfections. We have so far accumulated experience of burnup of metallic fuel elements to about 1,200 MW. days/ton in Calder Hall. Fuel elements are undamaged at this burnup and we are steadily extending our experience. The Electricity Authority reactors will operate fuel elements at higher temperatures and ratings. The main new phenomenon to be looked for is swelling of the uranium due to collection of fission gases in bubbles. This could lead to appreciable changes of volume, though we do not expect these to exceed about 10 per cent. The magnesium alloy cans have been designed to withstand volume changes of about 25 per cent. Recently we have shown that the observed swelling in small specimens can be much influenced by temperature cycles, and by restraining the amplitude of the cycling the swelling can be substantially reduced.

It has been stated by the Electricity Authority that with a 75 per cent load factor, 5 per cent interest rate and 20-year write off, and a burnup of 3,000 MW. days/ton, the Somerset nuclear power station just about breaks even, since it is situated in an area remote from coal-fields and conventional fuel costs are consequently high.

The American design thought to be most competitive is typified by the Dresden 180-MW. power station. This is served by a dual-cycle boiling-water reactor. The steam – water mixture produced in the reactor core flows from the reactor vessel to a primary steam drum at the reactor pressure of 1,000 lb./sq. in. The steam then flows to the turbine through the primary steam lines, and the water flows to the secondary steam generator where additional energy is removed to produce steam at a low pressure of 500 lb./sq. in. Valuable information on the stability characteristics of boiling-water reactors has been obtained from the experimental boiling-water reactors at the Argonne Laboratory, at Arco and at Vallecitos.

The contract price of the Dresden nuclear reactor was quoted as about £85 per kilowatt exclusive of research and development costs and fuel charges. The actual costs were stated to be higher than the contract price. The Dresden reactor had a fuel charge of 60 tons of uranium containing 1·5 per cent uranium-235 in the form of uranium oxide clad with zirconium. A burnup of 10,000 MW. days/ton is assumed in the economic forecast. Fuel is costed at American prices of the order of £50,000 per ton, and is to be hired at 4 per cent from the U.S. Atomic Energy Commission. The operator has, in addition, to pay for the uranium-235 burnt. On this basis, fuel costs are likely to be at least 3 mils per kWh. and overall costs were stated to be 7·5 mils. Since, however, the actual capital costs were not stated, this does not mean that commercial nuclear power has arrived in the United States. Indeed, it was stated at Geneva that in the United States nuclear power stations could not reach parity with commercial power before the stations which would start to be built in the late 1960's. This reflects the low present cost of power generated from cheap Kentucky coal or natural gas or hydro-power.

In other countries the date for reaching parity will depend on the cost of indigenous or imported fuel, the interest rates and the load factor available. The World Bank reported at Geneva an interesting study in the economics of nuclear power for a 130–150 MW. station to be erected in southern Italy. Bids were obtained from nine industrial organizations in the United States, Great Britain and France. The results were summarized in Geneva. Nuclear power costs for the most favoured bid were expected to be about 10 per cent above the cost of power from oil- (coal-) fired stations using oil (coal) at £9 10s. per long ton. This assumes a return on investment of 14 per cent and a load factor of 80 per cent.

The Geneva Conference also gave a forecast of the developments in progress towards the third generation of nuclear power stations, which may come into operation in the late 1960's. The major United Kingdom objective will be to reduce capital costs 20–30 per cent below those achieved from the improvement in the second-generation power stations. Capital costs can be reduced by increase of rating, so that more output can be obtained for a given volume of reactor. However, the reactor is already contributing less than 40 per cent of the whole cost. Heat exchangers and the conventional power house contribute more than half the cost. So their costs

must also be substantially reduced. This can only be done by increasing the temperature of operation and improving steam conditions.

In Britain an advanced gas-cooled reactor nuclear power station is being built as a reactor experiment to produce the advanced techniques which will be necessary to achieve this. The reactor will use uranium oxide fuel canned in beryllium. This should enable surface fuel temperature to be run to 600° C., giving an outlet temperature for bulk gas of between 500° and 570° C. The fuel elements will consist of a bundle of rods of small diameter. The reactor rating will then be increased from the 2·3 MW. per ton at Hinkley Point to about 8 MW. per ton. The reactor experiment will develop 100 MW. thermal and 28 MW. electrical. Since the plant will be purely experimental, a single-pressure steam cycle will be used with the modest steam condition of 600 lb./sq. in. An appreciably higher efficiency should be obtained with the more complex steam cycle which will be possible in the full-scale power station designed to use this advanced technology.

The use of uranium oxide fuel will require a slight degree of enrichment of the uranium—roughly 1·2 per cent of uranium-235 in the reactor experiment and a lower enrichment for full-scale stations. The enrichment could be provided by plutonium oxide from the second generation of nuclear power stations. Uranium oxide fuel is now being intensively studied, and especially valuable reports came from Chalk River. The fuel has great stability to irradiation, though it cracks as a result of thermal shock, so that it relies on the can for restraint. American companies, backed by a guarantee from the U.S. Atomic Energy Commission, are promising a burnup of 10,000 MW. days/ton, and small specimens are reported to have withstood 25,000 MW. days/ton without appreciable damage.

The present Canadian philosophy of power reactor development is to use a heavy-water moderator, allowing natural uranium oxide fuel to be used. It is then hoped to achieve a burnup of the order of 8,000 MW. days/ton and to write off the fuel at the end of the cycle. In this way it is hoped to achieve fuel costs declining from 1·5 mils to 1 mil and so achieve competitive nuclear power in Canada. The heavy-water gas, or water or steam-cooled reactor is undoubtedly one of the serious competitors for a place in the nuclear power station of the future.

We also heard of the progress of three recent experiments employing a different technology. The 10-MW. organic liquid – moderated reactor experiment at Arco uses a diphenyl or terphenyl moderator. This has a comparatively high stability to irradiation, about 100 lb. of polymer being formed per MW. day of heat. Coolant make-up costs 0·75–1·8 mils per electrical kWh., with a present probable value of about 1·2 mils. The use of an organic moderator has the advantage of a low pressure of about 13 atmospheres, with the surface temperature of fuel elements at 420° C. and a temperature of the bulk coolant ranging from 260° to 270° C. Another attractive feature of cooling by organic liquid is the low level of radioactivity of the coolant, which makes possible maintenance of the primary circuit, even during reactor operation. The reactor uses cermet fuel elements consisting of a 20-mil plate of uranium oxide in stainless steel clad in 5 mils of stainless steel. 26 kgm. of uranium-235 are used.

Good operational experience has been reported for this reactor. The system shows considerable promise for ship propulsion and for power stations with output in the 10–30-MW. range. It should have low capital costs, though whether these can be competitive with Diesel propulsion units remains to be seen. Fuel costs at the prices of American enriched fuel and loan charge would be expected to break even with the costs of oil fuel for ship propulsion systems.

The sodium-cooled graphite-moderated reactor experiment at the North American Aviation Company represents another experiment in reactor technology. The use of liquid sodium as a coolant offers the technical advantage of a high operating temperature with moderate pressure. These are offset by the compatibility problems characteristic of liquid sodium and the consequent need to keep the oxygen content at a level of a few parts per million. The graphite moderator has to be separated from the liquid sodium since it is not compatible with it, so that the graphite bricks are canned in zirconium, which is somewhat of a complication. We carried out a detailed design study on this reactor in the United Kingdom and have decided not to proceed with it.

The Oak Ridge homogeneous aqueous 10-MW. reactor experiment was also described. In this reactor a fluid fuel of uranyl sulphate is contained in a zircalloy core vessel. This is surrounded by a blanket containing a slurry of thorium oxide which captures escaping neutrons and so gives the reactor a breeding potential. Two difficulties have occurred in this reactor. First, corrosion of the wall of the core vessel led to a leakage from core to blanket, so the reactor has at present to operate as a one-zone system. Secondly, there are problems concerned with the stability of the liquid fuel. The future of this reactor system will depend on the results of the experimental programme.

The fast reactor constitutes the fourth class of reactor experiments. So far, only experience on the American 1-MW. fast reactor has been reported. The experiment showed that instabilities occurred due to the geometry of the core fuel rods. This has now been redesigned and the difficulty eliminated. 60-MW. reactor experiments are due to be commissioned in the United Kingdom in 1959 and in the United States in 1960, and a 5-MW. reactor experiment is just going into operation in the U.S.S.R.

Fast reactors have a core of very small size and a corresponding very high rating. For this reason their capital costs should be low. On the other hand, the fact of a large rating produces severe technological problems, and only experience with the reactor experiment will show whether they can be solved. Fuel costs should in principle be low, since they would be fuelled by plutonium from second-generation reactors, presumably at the 'civil price' of about £5 per gm. The reactor should have a breeding factor of at least 1·5 and should turn over the fuel in about 1,000 days. The fuel costs will, however, be dominated by the number of times it is necessary to re-process the fuel during its life, and the cost of making the re-processed fuel into new fuel elements. To minimize these costs, the United States and the United Kingdom are developing the so-called pyro-metallurgical processing system, in which the fuel is melted and the unwanted fission products skimmed off, leaving behind some fission products which, when alloyed with plutonium, have been shown to have good stability to radiation. Until we know more about

re-cycling costs, the economic future of fast reactors will remain obscure.

The technical feasibility of the nuclear propulsion of shipping has been abundantly demonstrated by the voyages of the U.S. submarine *Nautilus*, culminating in the remarkable voyage underneath the polar ice cap. The pressurized-water reactor used to develop steam for its propulsion has proved to be highly reliable. We heard at Geneva of the first approaches to commercial nuclear propulsion. The U.S. *Savannah*, a combined passenger-cargo ship coming into commission in 1960, will use a pressurized-water reactor developing 22,000 shaft horse-power. The pressurized-water propulsion unit seems likely to achieve fuel costs based on American prices about equal to those for oil fuel. Present capital costs are, however, three to four times higher than conventional capital costs, and a drastic reduction of these costs is necessary before parity with conventional propulsion is achieved. American engineers expect to build a nuclear tanker using a boiling-water reactor for propulsion by 1962. Since this type of reactor appears to have lower capital costs than the pressurized-water reactor, this should help to bridge the gap, though operating costs will still be well above conventional costs. It seems likely that we shall have to wait five years or more before we shall know whether truly commercial nuclear propulsion is a feasibility. However, there is one immediate application which would be impossible without nuclear power. The opening up of the 6,000-mile seaway north of the U.S.S.R. has had to wait for the practically unlimited endurance of the nuclear propulsion unit. The ice-breaker *Lenin*, which is due to be commissioned in 1959, will have three pressurized-water reactors installed, and two of these will provide 44,000 shaft horse-power for propulsion.

In contrast with the hopeful outlook for marine applications, commercial nuclear aircraft propulsion seems much further away.

EFFECTS OF WEATHER ON PLANT BEHAVIOUR

By Prof. J. P. HUDSON

Department of Horticulture, University of Nottingham School of Agriculture, Sutton Bonington

CROP yields vary enormously from year to year and from farm to farm, but record crops, produced by the best managers in exceptionally favourable seasons, show how far yields usually fall below the full cropping capacity of the varieties which are at present available. One of the challenges in agronomy is to show how average yields could be increased. Since 'the weather' plays such an important part in determining the behaviour of plants, a more precise knowledge of the effects of environmental factors would be extremely useful in agriculture. In the first place, knowledge of varietal preferences would make it easier to select the variety most likely to yield heavily in any particular site, provided sufficient meteorological data were available to enable the pattern of probable weather conditions to be forecast. Thus the critical matching of variety to district, on which successful agriculture largely depends, would be placed on a firmer footing than by the traditional and time-consuming method of trial and error.

Another advantage of a fuller knowledge of response to environment is that, once the plant's requirements are known, it is sometimes practicable to exercise a degree of control over the environment itself, to provide conditions which are more nearly optimal for growth. An obvious example is the control of soil moisture and soil salinity, by the complementary techniques of irrigation and drainage, which now make it possible for crops to be grown on some two hundred million acres of land throughout the world which could not otherwise be used for agriculture. Less spectacular, though still useful, methods of environmental control on an agricultural scale are the reduction of air speeds by the use of windbreaks, and the reduction of light intensity by the use of shade trees in the production of some plantation crops. In horticulture, the grower often goes much further by using devices like cloches, frames and heated glasshouses which change such factors as temperature, wind speed and, to a lesser extent, light.

Much research is now being done on the effects of environmental factors on plant behaviour[1,2] and the possibilities of controlling these factors in crop production, but the position is frustrating. Apart from the control of water, and reduction of wind and light intensity, there seems to be little hope of affecting the other physical factors of the environment on a field scale. This is particularly the case with the two important factors of temperature and day-length, both of which have profound effects on the behaviour of many crop plants, and it is difficult to see how control of physical factors of the environment (apart from water) can make any substantial contribution to increasing yields of the major food crops in the immediate future. This is an unwelcome conclusion to those who are working on the agronomical uses of environmental control, but one which must nevertheless be accepted.

However, there is another possible approach. If it is impracticable to affect plant behaviour in the field by altering the nature of its environment, might it not be possible to alter the plant's responses to the natural environment? For example, the use of a chemical treatment to affect the responses of a plant to temperature or day-length would be a much more elegant device than to try to alter those weather factors on a field scale. The results of some recent experiments suggest that this approach is worth considering.

The work has mainly been done on the raspberry (*Rubus idaeus* L.), which is not itself of much importance in world cropping, but was chosen because of its great convenience as an experimental plant. The pattern of the work has been, first, to study the behaviour of the species in the field, in order to distinguish between successive phases in the life-cycle, with particular emphasis on the behaviour of the stem apices. Next, plants have been grown in

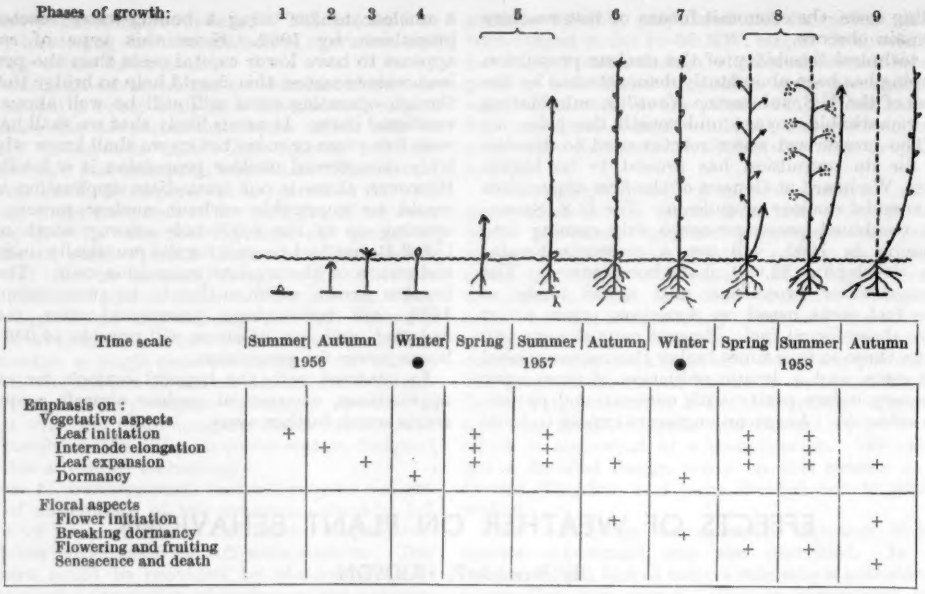

Fig. 1. Diagram showing the phases of development of a raspberry shoot growing in a temperate climate, and the behaviour of the apical meristem(s) characteristic of each phase

controlled environments (growth rooms), to ascertain which types of 'weather' (that is, which levels of temperature, day-length and/or light intensity) cause the shoots to pass from one phase of development to the next. Thirdly, plants have been grown in environments which represented marginal weather conditions, where shoots are just 'held' in one phase and prevented from progressing to the next, and the shoots have then been treated with chemical stimulants to see whether they could be induced to pass to the next phase in weather conditions which would normally prevent that development from occurring.

The raspberry plant lends itself to such an investigation since suckers which arise from adventitious buds on the perennial root systems have life-cycles which can be divided into a number of discrete phases, in each of which the apices behave in different ways (Fig. 1). Under natural weather conditions in a temperate climate, leaf initials are laid down in the subterranean bud in phase 1, internodes elongate to carry the apex to the soil surface in phase 2, while leaves expand in phase 3, but internodes cease to elongate, and a rosette of leaves is formed. Thus, in the first three phases the three major phenomena of vegetative apices, namely, leaf initiation, internode elongation and leaf expansion, are each dominant in turn. The shoot then becomes dormant through the first winter, in phase 4, while in phase 5, which starts in the spring, leaf initiation, leaf expansion and internode elongation occur simultaneously. In phase 6, which occurs in the late summer or autumn in temperate climates, the shoot apex produces a rosette of leaves (and occasionally flower initials in some varieties), while the apices in most of the axillary buds change from the vegetative to flowering condition, until the shoot again becomes apparently dormant in phase 7. During this phase the condition of dormancy is broken by winter cold, but elongation does not start until the spring, when the axillary buds produce short lateral shoots, which bear leaves, flowers and, finally, fruits (phase 8). The cycle is completed in phase 9, when most of the shoot dies after fruiting, except for a short length at the base, near ground-level, from which a replacement shoot has meanwhile grown, to repeat the phases and continue the cycle of annual fruiting in the following year.

The phases of growth thus provide meristems in the following series of different conditions, and it is because of this succession, and the occurrence of phases in which meristematic activities are separable, that the species is of such interest :

	Phase
Vegetative apex :	
Emphasis on leaf initiation	1
Emphasis on internode elongation	2
Emphasis on leaf expansion	3
Dormant	4
Initiation, elongation and expansion occur simultaneously	5
Flowering apex :	
Flower initiation	6
Breaking of dormancy	7
Flower expansion to fruiting	8
Senescence and death	9

Since these phases are observed to occur with great regularity at particular seasons of the year in temperate climates, it was assumed that the progression from phase to phase was mainly the result of seasonal changes in the environment, and this aspect has been investigated further. My colleague, Dr. I. H. Williams, has elucidated the main effects of environment on development of the raspberry plant in a series of elegant experiments in four simple growth rooms where temperature, day-length and light intensity were controlled[3,4]. Williams has shown that differences in the behaviour of the apical meristem are largely brought about by changes in temperature and day-length, but there is an additional factor, in some phases, of 'ripeness to proceed' to the next phase, since it seems necessary for shoots to remain for a minimum period in some phases before they can enter upon the next even though

Fig. 2. Raspberry plants, all 32 weeks old, showing the effects of environmental factors on behaviour. Plants subjected to various combinations of 'summer', 'autumn' and 'winter' conditions in growth rooms show (left to right) a plant maintained in the rosette condition; one which has made continuous growth and is now 7 ft. high; a shoot in the winter dormant phase; and a plant with 'second-year' fruiting laterals in flower (left) and a new basal replacement shoot (right)

environmental conditions are conducive to that move.

Williams has also shown that the raspberry shoot can be maintained in some of the phases for far longer than the normal period, but that successive phases can also be telescoped by moving plants from one environment to another as soon as they are ripe for the next phase. Indeed, he has been able to reduce the time spent in each phase to such an extent that ripe fruits have been produced in several experiments little more than six months after the shoots had been initiated as buds on raspberry roots, thus reducing to a quarter the time which the complete cycle normally takes in Nature (Fig. 2).

It is thus quite feasible to affect the behaviour of this species by altering the nature of its physical environment, but work is now concentrating on methods of inducing shoots to pass to the next phase without changing the environment. The rosetted shoot (phase 3) has been chosen for this work, since it is at that time 'ripe to proceed' but is prevented from growing into a vigorously elongating leafy shoot by adverse weather conditions, which normally induce a period of dormancy in temperate climates. In most of the experiments elongating plants, grown at 18° C. and 12 hr. days, have been put into an environment with a lower temperature (10° C.) and shorter

Fig. 4. Raspberry plants after 16 weeks in a growth room at 10° C. and 8 hr. day. Left to right: control plant with terminal rosette of leaves; plant treated with 1 μgm. gibberellic acid weekly from the outset; treated 1 μgm. weekly after rosette began to form; treated 1 μgm. weekly after rosette was fully formed. The shoot has continued to grow in the second and third plants, and recommenced growth from the rosette in the fourth

days (8 hr.), under which conditions they will normally form terminal rosettes of leaves within two or three weeks and thereafter remain in the rosetted condition for many months, slowly unfolding new leaves but with no elongation of the internodes (Fig. 3). Various chemicals have been applied to the stem apices, with outstanding results from the use of gibberellic acid, as might be expected from the effects which this remarkable growth-regulating compound has been shown to have on other species[5]. If elongating plants are put into this environment and are immediately given weekly treatments of 1–2 μgm. of gibberellic acid per plant, applied to the tip of the shoots with a micropipette, they continue to elongate steadily, unfolding new leaves (Fig. 4). On the other hand, if plants are allowed to form rosettes and are then given similar treatment they will recommence to elongate at once (Fig. 5). If the applications cease, the effect of the gibberellic acid wears off within a few weeks and the shoot once more rosettes, while re-introduction of the treatment a few weeks later causes elongation to recommence, with further leaf expansion, and so on. Thus, weekly applications of gibberellic acid at a low concentration will prevent raspberry shoots from rosetting, or will cause rosetted shoots to recommence elongation, under environmental conditions which would normally induce rosetting and maintain shoots indefinitely

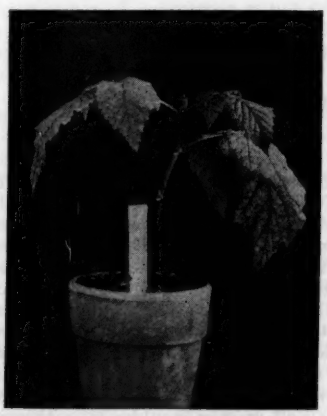

Fig. 3. Raspberry shoot showing a terminal rosette of leaves induced by putting a rapidly growing plant into a temperature of 10° C. and day-length of 8 hr.

Fig. 5. Shoot recommencing to elongate from a terminal rosette (indicated by arrow) after being treated with gibberellic acid in an environment which would normally maintain the plant in the rosetted condition

Fig. 6. Plant grown for six months at 10° C. and 8-hr. day. After forming a terminal rosette the original shoot (left) was treated with gibberellic acid, which caused it to recommence elongating and at the same time stimulated a basal shoot to grow (right) although that shoot was not treated at any time. When treatment of the left-hand shoot ceased after a few weeks it formed a new terminal rosette but the new shoot continued to elongate without rosetting

in that condition. Treatment with gibberellic acid, particularly after rosetting, also has the effect of stimulating the basal bud into growth, even though no acid is at any time applied to that bud or shoot, and there is a curious tendency for the new basal shoot to continue to elongate even after treatment with gibberellic acid has ceased and the original shoot has reverted to the rosetted condition (Fig. 6).

Heavier applications of gibberellic acid (for example, a single treatment with 200 μgm.) cause very rapid and abnormal elongation both of the rosetted apex and of the basal bud, which would not normally elongate until the following year, and the effects of such a single application persist for at least three months.

The importance of these results is that treatment with gibberellic acid changes the reaction of the plant to its environment, in this case causing a shoot to grow (that is, increase in length and leaf area) under weather conditions which would normally prevent it from elongating. By the use of appropriate dosages the growth made under the stimulus of gibberellic acid is quite normal and healthy.

Although the work on raspberry has little apparent application to general crop husbandry, it is not difficult to see the significance of these results. For various reasons such as risk of late frost or technical difficulties of cultivation, it is often necessary to delay the sowing or planting of crops, which make slow growth at first and may still be small when optimal growing conditions occur later in the season[6]. Earlier sowings may be useless in practice, since the young plants may fail to make appreciable growth under sub-optimal conditions of low temperatures or short days. However, if at this stage growth could be stimulated by chemical treatment under marginal weather conditions, but without causing the plant to initiate flower primordia, a larger plant might be produced by the beginning of the growing season, capable of taking full advantage of seasonal improvements in the weather. Crops might then make more total growth or might ripen earlier, or both.

The word 'marginal' is stressed. There is likely to be little profit in forcing plants to grow under dangerously sub-optimal conditions, and there might even be a risk of losing the crop altogether; but the careful control of plant behaviour in response to certain marginal weather conditions might offer a technique of considerable practical value in agriculture, enabling the farmer for the first time to break the grip of the weather on his crops. The work will continue in this Department with raspberries and a few other species, but the purpose of this article is to suggest that it might be worth while to make similar investigations on the major world crop species in centres where facilities exist for that type of work.

I am grateful to my colleague, Miss J. M. Cook, for the use of some unpublished results of her experimental contribution to this work.

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STRUCTURE AND REACTIONS IN ORGANIC CHEMISTRY

THE KEKULÉ SYMPOSIUM

A SYMPOSIUM on Theoretical Organic Chemistry was held in London during September 15–17 in celebration of the centenary of the discovery by Kekulé of the quadrivalency of carbon. Organized by the Chemical Society on behalf of the Organic Chemistry Section of the International Union of Pure and Applied Chemistry, the meetings were devoted to invited lectures and papers on chemical binding and structure, nucleophilic reactions, and electrophilic and homolytic reactions. The proceedings will be published in full.

It is probably true to say that no single paper has had so fundamental and far-reaching an influence on the development of organic chemistry as has Kekulé's paper of 1858 on "The Constitution and Metamorphosis of Chemical Compounds and the Chemical Nature of Carbon" (*Annalen der Chemie*, **106**, 129; 1858). It was in this paper that Kekulé clearly recognized that carbon is tetravalent and that carbon atoms can link together. These two concepts produced order out of chaos, led to the confirmation of the principle of homology, to the idea of closed rings and, in 1865, to the structure of benzene itself. Modern structural organic chemistry had begun, and the decades that followed saw the very rapid development of the subject which, with advancing years, included natural products and synthetic compounds of greater and greater complexity within its understanding. It was fitting, too, that this symposium should be held in London, because in 1854 Kekulé

was appointed as private assistant to J. Stenhouse at St. Bartholomew's Hospital, and it was while travelling on the upper deck of a Clapham omnibus on the return journey from a visit to Hugo Müller at Islington that he first conceived the basis of his now famous *Strukturtheorie*.

The symposium was formally opened by Prof. H. J. Emeléus (Cambridge), the president of the Chemical Society. Each of the three days opened with a lecture, which was followed by the reading of five papers. Sir Christopher Ingold (London), Prof. W. Doering (Yale) and Prof. R. Huisgen (Munich) acted as chairmen.

The symposium opened with a lecture by Prof. L. Pauling (Pasadena) on the nature of the double bond and of conjugated and aromatic molecules. He pointed out that, although the nature of the single bond is now well understood, there still remains some doubt about the best description of multiple bonds and of the structures of molecules in which these bonds are considered to play a part. Of the two ways of describing the double bond—first, as composed of a σ- and a π-bond, and secondly, as composed of two equivalent 'bent bonds', the second was preferred. "Bent bonds", it was maintained, "are best". The two descriptions are equivalent in the approximation in which the bond orbitals are *sp*-hybrids, but the inclusion of contributions from *d*, *f*, etc., orbitals to the bond orbitals results in concentration of the orbitals in the direction of the bond, and causes the two descriptions to differ significantly. In these circumstances, the 'bent bond' description was shown to afford superior interpretations of the observed magnitude of potential barriers to rotation about certain single bonds adjacent to multiple bonds, of the ratios between single, double and triple bond-lengths, and of observed bond-angles. Some implications of the 'bent bond' concept in considerations of the structure of aromatic compounds were also discussed.

A comparison of the results of the resonance and molecular-orbital theories when applied to the ground states of some π-electron systems was given by Prof. H. C. Longuet-Higgins (Cambridge). It was shown that the molecular-orbital theory is to be preferred in the treatment of molecules such as *cyclo*butadiene and diphenylene, containing unsaturated rings in which the number of π-electrons is not of the form $(4n + 2)$. The use of localization energies for predicting the reactivities of molecules in both heterolytic and homolytic reactions was also illustrated. Further work on the theory of aromatic character was described by Prof. D. P. Craig (London), in which the possibilities of π-electron delocalization of orbitals other than $p\pi$, such as $d\pi$ and $f\pi$, were considered. In this wider framework aromaticity can be of two distinct kinds. Apart from the normal, or 'homomorphic' aromaticity, which is characterized by the prime role of the aromatic sextet, a second kind, called 'heteromorphic' aromaticity, is expected to occur in cyclic systems of alternating $p\pi$- and $d\pi$-orbitals, and should show no special preference for a sextet over an octet. Some features of the six- and eight-membered cyclic phosphonitrilic halides are compatible with delocalization of this type, and there are indications of the wider occurrence of this kind of aromaticity. The problems involved in the synthesis of new structural types possessing aromatic character were discussed by Prof. W. Doering (Yale). The structures discussed included the tropylium ion $C_7H_7^+$, and its relatives, tropone and tropolone. Among neutral molecules, in the five-membered series fulvene, C_6H_6, has recently been obtained, and also probably fulvalene, $C_{10}H_8$, by an arduous removal of four hydrogen atoms from two molecules of *cyclo*pentadiene. In the seven-membered series heptafulvene, C_8H_8, has been obtained in solution as an unstable, deep-red compound, and heptafulvalene, $C_{14}H_{12}$, has been obtained as a violet-red crystalline substance.

Attempts to provide quantitative experimental results to support quantum-mechanical calculations on conjugated systems by Kistiakowsky's classic method of measurement of heats of hydrogenation were described by Prof. R. B. Turner (Houston). In the more recent experiments described, it has been possible to apply corrections for steric strain energies to the measured total stabilization energies. Such corrections were shown in some instances to be large and important. In the last paper of the first day, Prof. C. A. Coulson (Oxford) discussed the influence of steric deformation and consequent departures from exact planarity on the π-electron structure of conjugated and aromatic molecules. The several distinct situations which can arise, namely, rotation about a formally single bond, as in diphenyl, large polynuclear over-crowded hydrocarbons like dibenzophenanthrene, where the strain is distributed over the whole molecule, phenanthrene-type distortions in which hydrogen atoms are displaced out of the plane, and buckled rings such as hexachlorobenzene, were considered separately.

The second day of the symposium was opened by Sir Christopher Ingold (London), who delivered a lecture on "Nucleophilic Octahedral Substitution". The displacement of the ligand X as an anion from various cobaltic ions of the form $(Co\ en_2AX)^+$ is typical of this class of reaction, in which the regular space-figure involved is an octahedron. The kinetic characteristics of these reactions point to the dominance of two mechanisms, analogous to the known organic-chemical mechanisms S_N1 and S_N2. The analogy extends fairly closely to the effects of substituent groups and of the nucleophilic capacity of the reagent on reactions by both mechanisms. The interpretation of the stereochemical results of these substitution reactions is complicated by the circumstance that the geometrical correlation between experimental result and molecular cause is less clear-cut in octahedral than in tetrahedral substitution. It appears that neither S_N1- nor S_N2-type octahedral substitutions by anions are stereochemically specific, although the latter show evidence of orientation, by the preserved ligands, caused principally by conjugative electron-displacement. However, octahedral substitutions of chloride ion by neutral water appear to proceed uniformly without stereochemical change. The theoretical implications of these findings and, in particular, of the differences between the neutral and anionic reagents, were discussed in detail.

Prof. J. D. Roberts (Pasadena) discussed the results of a kinetic investigation into the hydrolysis of diaryliodonium salts to phenols and aryl iodides. The reaction was studied under conditions likely to give rise to an S_N1 mechanism, since under these conditions phenyl cations might be expected to be produced. However, the rather unexpected results which were obtained on the effects of substituent groups on the distribution of products, and the catalytic effects of oxygen, acids and copper salts

were taken as an indication that the complete reaction, which can be described as a nucleophilic substitution, involves the intermediate formation of solvent-caged free radicals. Recent research on the phenomena of fragmentation in solvolytic reactions was described by Prof. C. A. Grob (Basle). The heterolysis of a bond to an electron-acquiring group X in a system a–b–c–d–X may lead to the heterolysis of the bond between b and c, resulting in fragmentation (β-cleavage) of the molecule, as well as to the well-understood processes of substitution, elimination and rearrangement :

$$a - b - c - d - X \rightarrow a \rightarrow b^{+} + c = d + X^{-}$$

This can occur if a is an electron-donating group, and is particularly prevalent in γ-amino-halides, where a is $-NR_2$. Two unimolecular mechanisms for the fragmentation have been found to be operative, namely, a one-step process in which ionization of X and cleavage of the C_β—C_γ bond are synchronous, and a two-step mechanism in which the rate-determining ionization is followed by a faster product-determining step, which can lead to fragmentation or to other processes.

A review of recent progress in conformational analysis was given by Prof. D. H. R. Barton (London). The subjects discussed included the rearrangement of diaxial products of addition reactions to the *cyclo*hexene system to the corresponding diequatorial isomers, which was illustrated by new rearrangement reactions of halohydrin esters. After a review, in conformational terms, of the behaviour of carbanions, Prof. Barton concluded his paper with a discussion of long-range group effects in large saturated molecules, such as steroid and other systems. It was concluded that these effects are transmitted by the successive distortion of valence angles. The effect is referred to as 'conformational transmission'. The S_N2 mechanism of substitution at aromatic and other unsaturated centres was discussed in a paper by Dr. J. F. Bunnett (Providence). It was shown that in contrast to the synchronous S_N2 mechanism of substitution at a saturated carbon atom, the S_N2 mechanism in these examples involves the formation of metastable intermediate complexes. Often the bond to the incoming group is completed before the bond to the outgoing group starts to be broken. It is possible that the strictly synchronous S_N2 mechanism is unique for displacements at saturated carbon. The role of 'benzyne' intermediates in rearrangements observed during nucleophilic aromatic substitutions with alkali amides or organolithium compounds was reviewed by Prof. R. Huisgen (Munich). Recent investigations were described which establish the mechanism more firmly and resolve some of the discrepancies attendant upon it.

Prof. M. J. S. Dewar (London) opened the last day of the symposium with a lecture on "Rearrangements in Aromatic Compounds". These rearrangements were classified and their possible mechanisms, including the intramolecular mechanism involving the formation of π-complexes, were discussed. New experimental work on the rearrangements of N-bromoacylanilide derivatives, and the acid-catalysed rearrangements of alkyl aryl ethers, was described. Both these rearrangements appear to be intermolecular. The mechanism of the benzidine and related rearrangements was discussed in the light of known experimental data, and the intramolecular mechanism previously suggested by Prof. Dewar was shown to be not inconsistent with the recently discovered dependence of the rate of rearrangement on the square of the concentration of the acid catalyst.

Researches on the mechanism of nitration were reviewed by Prof. E. D. Hughes (London). Although the mechanism of nitration via the nitronium ion is very common, the paper included a discussion of nitration via nitrosation, and C-nitration via N-nitration and rearrangement. Work on O-nitration, which also proceeds via the nitronium ion, was discussed. Some recent studies of reactivity and orientation in aromatic halogen substitution reactions were described by Dr. P. B. D. de la Mare (London). Halogenation can take place either directly, by the molecular reagent, or with the intermediate formation of chlorine or bromine cations, or their hydrated forms. The conclusion that the inductive effects of substituent groups are less important in determining orientation in substitution by molecular than by charged species was reached from a consideration of recent work on halogenation, and was discussed in terms of the transition states for the two modes of substitution.

Recent evidence for the operation of quasi-heterolytic mechanisms for reactions in the gas phase was presented by Dr. A. Maccoll (London). The reactions considered, for which such mechanisms appear to be correct, were the unimolecular dehydrohalogenation of alkyl halides and olefin elimination from esters. The first group shows close similarities to the S_N1 and $E1$, and the second to the $E2$, mechanisms for reactions in solution. The possibility of acid catalysis in the gas phase was discussed with reference to the elimination of olefins from alcohols catalysed by hydrogen halides. The remaining two papers dealt with homolytic reactions. Prof. D. H. Hey (London) described recent work on reactions of aroyl peroxides with naphthalene. The formation of arylnaphthalenes, naphthyl esters and dinaphthyls, and the proportions in which the various isomers of these substances were formed, were rationalized in terms of the various substitution and hydrogen-abstraction reactions which may occur with radicals of different polar and steric requirements. Recent measurements of the methyl (alkyl) affinities of various aromatic compounds and olefins were presented and discussed by Prof. M. Szwarc (Syracuse). The relationship between the experimental results and theoretical calculations of localization energies was shown to be consistent with a model of the transition state for attack by alkyl radicals in which the repulsion between the radical and the molecule and the attraction between the same radical and the 'residual' molecule (that is, a hypothetical molecule in which an electron is localized on one of the carbon centres) are balanced.

On the evening of September 15 those attending the symposium were invited by the University of London to a reception by the Vice-Chancellor (Dr. C. F. Harris) at the Senate House. On the following evening the Kekulé Symposium dinner was held at the Connaught Rooms, at which the speakers were Prof. H. J. Emeléus (president of the Chemical Society), Prof. P. E. Verkade (president of the Section of Organic Chemistry of the International Union of Pure and Applied Chemistry) and Prof. R. Huisgen.

D. H. Hey
G. H. Williams

OBITUARIES

Prof. K. S. Lashley, For.Mem.R.S.

KARL SPENCER LASHLEY was born in West Virginia on June 7, 1890. He died in Paris in August 1958.

Whatever may turn out to be the correct detailed story of nerve conduction and the localization of mental functions in the brain, it is safe to say that Lashley's work will always stand distinguished for the brilliance of his experimental attack, for the originality and sweep of his ideas, and for the incisiveness and clarity of his exposition.

Lashley received his scientific training, about equally in zoology and in psychology, at the Universities of West Virginia, Pittsburgh and Johns Hopkins. He became a professor of psychology first in the University of Minnesota and then at Chicago. In 1937 he was appointed research professor of neurophysiology at Harvard, and five years later he also became director of the Yerkes Laboratories of Primate Biology at Grange Park, Florida. It was in Florida, in his home there, working among his chimpanzees, with his carefully chosen band of students, and often piloting his small sailing boat, mostly alone in coastal waters, that he spent, probably, the happiest years of his life.

Some of Lashley's early work was carried out in conjunction first with H. S. Jennings, and later with the behaviourist, J. B. Watson. But he never, all his life, for long allowed himself to stay tied to anybody else, or to theories other than his own. Perhaps it was their unconventional character, and the fact that they were rebelling against respectable and established opinions of their day, which attracted him in turn to behaviourism, to Pavlovian conditioned reflex theory; and then, by what seemed rather like a complete somersault, to *Gestalt* psychology, and even to some of the more romantic aspects of Freudism. All of these had some influence with him; none of them carried him away.

From 1912, when he published his first paper—on visual discrimination of size and form in the albino rat—to the middle 1920's, he was busy with many and varied experimental investigations in animal behaviour. These moved more and more definitely towards what he called "studies of cerebral function in learning". In 1929 he published his famous book "Brain Mechanisms and Intelligence", and this was very quickly recognized as of outstanding importance. Nearly everybody who writes now of this volume directs attention to Lashley's two principles of brain activity, which he called "Equipotentiality" and "Mass Action". Taken together and in a broad sense, these principles, and particularly the abundant, detailed and original evidence upon which they were based, expressed and demonstrated the view that there could be considerable loss or injury to brain tissues and still the behaviour functions subserved by the areas concerned could be carried on, though sometimes in ways new and different compared with those which had been learned. What particularly marked Lashley's neurophysiological approach was its loyalty, at the same time, to the highest and most exact standards of behaviour experimentation. Plenty of people have shown that it is easy to be scientifically exacting on one side, and little but dogmatic on the other; Lashley accepted and used the same rigour of research on both.

Until he moved to Florida and the chimpanzee colony, most of Lashley's experimental work had been carried out with rats. But with the opportunities which he now had, he began to devote more attention to studies of the neurophysiological foundations of some of the higher and more complex mental functions. In a broad sense, his views about the areal and patterned character of brain activities remained unchanged. He continued to publish a number of splendid papers, and he inspired notable experimental work by his students. But he ran into a period of prolonged ill-health. In the summer of this year he seemed to be better, and he set out upon one more journey to Great Britain and to France. He had been elected a Foreign Member of the Royal Society in 1951. On July 28 he signed the Charter book of the Society, and then continued his planned trip to France. There, in Paris, about a fortnight later, he died.

Lashley, superbly intelligent himself, liked people to be, in his judgment, intelligent. He very quickly made up his mind about this, and anybody who met him, though maybe only for a short time, and was accepted by him as up to the mark, could never forget his brilliant, rather wayward, and most lively habit of mind. Though he was a fine and patient experimenter, he was no laboratory recluse. High among more general interests were music—he was good with a violin—and sailing. Sometimes he said that he would have liked best of all to sail lonely voyages across the widest seas in some small boat. When he came to Europe he always preferred, if he could do so, to travel in a little tramp steamer; he disdained the luxury liner. Life to him was an adventure, a continuing opportunity for original exploration, whether in action or by thought, and if it could be very clear that the responsibility for whatever he found was wholly his own, that was all the better.

F. C. BARTLETT

The Rev. T. N. Burke-Gaffney, S.J.

WITH the death of Thomas Noel Burke-Gaffney on September 14, Australian seismology has suffered an almost irreplaceable loss.

Father Burke-Gaffney became director of the Riverview College Observatory in 1952 when the former director, Father D. J. K. O'Connell, was appointed director of the Vatican Astronomical Observatory. He occupied the post with distinction, and more than maintained the reputation which Riverview has held for fifty years as one of the world's first-class seismological observatories.

He was that rare type of seismologist to whom the records of each earthquake take on the form of a distinct personality. Through this faculty, he developed an insight into the reading of seismic records the like of which we may not see again in Australia. He was devoted to his work, and few outside the ranks of seismologists in Sydney and a small number of his close colleagues know of the extent to which he helped, beyond his strength, young seismologists in many parts of Australia to an understanding of the intricacies of seismic recording.

He played a valued part in Australia's International Geophysical Year work as convener of the

National Subcommittee on Seismology, and was for several years a member of the Council of the Royal Society of New South Wales. In these and related offices he gave of his best.

His published work includes seven papers on seismology, the last of which appeared in the *Australian Journal of Physics* shortly after his death. The papers were concerned with the seismicity of Australia, the problem of detecting *S* waves in the Earth's inner core, special phases from New Zealand earthquakes, and seismic aspects of nuclear explosions. The last work has attracted world-wide attention.

Father Burke-Gaffney was born in Dublin on December 26, 1893, and entered the Jesuit order in 1913. He took up residence in Australia in 1928 as senior science master at St. Ignatius's College, Riverview, Sydney, and in 1946 became assistant director of the College Observatory. He lived austerely, and was one of Australia's most unassuming scientists and a man of quiet, gentle dignity. Few outside his College friends and his seismological colleagues got to know him well; but those of us who did, knew him as a charming liberal-minded man graced with a delightful humour and who dedicated himself to his work.

K. E. Bullen

NEWS and VIEWS

Nobel Prize for Medicine and Physiology: Prof. J. Lederberg; Prof. G. W. Beadle and Dr. E. L. Tatum

The recent award of the Nobel Prize for Medicine and Physiology for 1958 to Prof. Joshua Lederberg, and jointly to Prof. G. W. Beadle and Dr. E. L. Tatum, is a signal acknowledgment of the great advances which have been made in knowledge of the genetics of micro-organisms in recent years, and of the importance of this knowledge to an understanding of living processes in general.

The main contribution of Beadle, the geneticist, in collaboration with Tatum, the chemist, was to show first, in 1941, that mutations induced by irradiation in the mould *Neurospora crassa* resulted in inability to synthesize specific chemical nutrients which the organism needed for growth. Genetic crosses between the mutant and parental strains invariably showed that each mutant strain, having a single specific requirement, differed from the parental strain by alteration of only a single gene. Thus single genes appeared to control single biochemical reactions and, by inference, the formation of single enzymes. This first successful attempt to relate genetic and biochemical function experimentally gave birth to the stimulating 'one gene, one enzyme' hypothesis and initiated the expanding field of biochemical genetics. In further studies Beadle and Tatum traced the synthetic defects of some of their mutant strains to inability to perform various specific intermediate steps in the chain of processes leading to formation of such required end-products as amino-acids or vitamins of the B group. By wedding experiments with such mutants to inspired guess-work concerning presumptive precursors in biosynthesis they, and many subsequent workers, have built up a formidable mass of knowledge about intermediary metabolism.

Tatum (1944–46) extended these *Neurospora* studies to bacteria. As a result, a considerable stock of nutritionally defective mutant strains of *Escherichia coli* were developed. Lederberg, who was working with Tatum at this time, conceived the idea that these mutants might be used to provide a definitive test of the occurrence of sexuality in bacteria. The experiments were immediately successful and were first reported jointly by Lederberg and Tatum in 1946 in *Nature*. Subsequent studies by Lederberg proved the existence of a linear linkage between many of the genes of *Escherichia coli*, thus showing, for the first time, that bacteria are fundamentally similar to other types of cell in their genetic and biochemical constitution. These studies, which then appeared to S. E. Luria "to be among the most fundamental advances in the whole history of bacterial science", served as the starting point for many far-reaching discoveries in the field of bacterial genetics which Lederberg has ever since continued to fertilize with new ideas and techniques. In 1952, he and Dr. N. D. Zinder showed that certain bacterial viruses (bacteriophages) could act as vectors of small fragments of bacterial chromosome from one cell to another so that recombinant types arose: development of this discovery, especially by Dr. M. Demerec and his colleagues, has provided important new concepts about the fine structure and function of the gene. In 1953, Lederberg and his wife, Dr. Esther M. Lederberg, simultaneously with Dr. E. Wollman of the Pasteur Institute, Paris, first proved that the genetic material of a bacterial virus of low virulence might attach itself to a specific site on the bacterial chromosome and thereafter be propagated indefinitely among the progeny of the host cell as though it were part of its normal hereditary constitution. Lederberg and his wife also developed a simple but elegant technique, known as 'replica plating', which, in addition to its wide applicability as a laboratory tool, was used by them to demonstrate directly, for the first time, that bacterial mutations, such as resistance to certain antibiotics or viruses, arose spontaneously and not in response to environmental stimuli.

Royal Society: Medal Awards

The following awards of medals have been made by the President and the Council of the Royal Society: *Copley Medal* to Prof. J. E. Littlewood, lately Rouse Ball professor of mathematics in the University of Cambridge, for his distinguished contributions to many branches of analysis, including Tauberian theory, the Riemann zeta function, and non-linear differential equations; *Rumford Medal* to Sir Thomas Merton, formerly professor of spectroscopy in the University of Oxford, for his distinguished researches in spectroscopy and optics; *Davy Medal* to Prof. R. G. W. Norrish, professor of physical chemistry in the University of Cambridge, for his distinguished work in chemical kinetics, especially in photochemistry; *Darwin Medal* to Sir Gavin de Beer, director of the British Museum (Natural History), for his distinguished contributions to evolutionary biology; *Sylvester Medal* to Prof. M. H. A. Newman, Fielden professor of mathematics in the University of Manchester, for his distinguished contributions to combinatory topology, Boolean algebras and mathematical logic; *Hughes Medal* to

Prof. E. N. da C. Andrade, emeritus professor of physics in the University of London, for his distinguished contributions to many branches of classical physics.

The Royal Society of Edinburgh

THE following officers and members of Council were elected at a meeting of the Royal Society of Edinburgh, held on October 27: *President*, Prof. J. Norman Davidson; *Vice-Presidents*, Prof. A. C. Aitken, Dr. J. E. Richey, Prof. D. Whitteridge, A. W. Young, Prof. E. L. Hirst, Prof. J. R. Matthews; *General Secretary*, Prof. Norman Feather; *Secretaries to Ordinary Meetings*, Dr. A. W. Greenwood and Dr. Mowbray Ritchie; *Treasurer*, Dr. J. R. Peddie; *Curator of Library and Museum*, Dr. Douglas Guthrie; *Ordinary Members of Council*, Dr. J. A. Macdonald, Dr. Robert Schlapp, Dr. J. B. Tait, Prof. G. M. Wyburn, Prof. R. A. Rankin, Prof. A. E. Ritchie, Prof. W. M. Smart, Prof. V. C. Wynne-Edwards, Prof. E. G. Cullwick, Prof. G. Pontecorvo, Prof. M. M. Swann, Prof. T. S. Westoll.

Zoological Society of London: Dr. D. Morris

THE Zoological Society of London has appointed a new curator of mammals, Dr. Desmond Morris, who will commence his duties on January 1, 1959. Dr. Morris graduated at the University of Birmingham and then moved to Oxford to study for a doctorate on animal behaviour under Dr. N. Tinbergen, and remained to expand his studies with several years of postdoctoral research. His work was mainly concerned with the analysis of aggressive, sexual, parental and social behaviour patterns in various vertebrate species. He published numerous papers on these subjects, including several monographs, in which attempts were made to unravel the whole social structure of particular species. Other papers dealt with modifications and extensions of certain behaviour concepts, such as displacement activities. His most important studies were in the field of animal communication, where he introduced the concept of 'typical intensity', and focused attention on the importance of autonomic signals in the evolution of animal language. Three years ago, Dr. Morris left Oxford to take up the post of head of the Granada Television and Film Unit at the Zoological Gardens, London, and has since devised and presented more than a hundred television programmes about animals. Working on these programmes inside the Zoo has given him wide experience of the Zoological Society's collection of mammals. This experience, combined with his knowledge of animal behaviour problems in general, will prove invaluable when he takes up his new appointment next January.

A New Higher Technological Award

THE National Council for Technological Awards has announced that in order to encourage qualified men and women to undertake further study beyond the level of the diploma in technology (Dip.Tech.) and to carry out original investigations, it has decided to create a higher award. It is intended that this award shall be a mark of distinction granted to a student who has proved his ability by completing a substantial programme of work demanding the application of his knowledge to the solution of a problem of value to industry. The Council will establish a new college, to be known as the College of Technologists, and the new award will take the form of membership of this College (M.C.T.). To qualify for this award a student must undertake a programme of work to be carried out jointly in industry and at a technical college. This programme may be concerned with any technological aspect of industrial activity, such as research, development, design, production or market investigation. The Council believes that to carry out successfully post-diploma work of this character, students must remain in contact with industry or with commercial laboratories. A candidate must apply for registration to the College of Technologists through the technical college at which he will study. The programme offered should be related to the student's experience in industry and have the approval of his employer. It should be likely to result in a useful contribution to technological knowledge and require industrial experience and academic study extending over a substantial period; a three-year period of work is envisaged, provided a high proportion of a student's time can be devoted to it. The work must be supervised by a member of the staff of the technical college at which it is undertaken and by a staff member of the industrial organization concerned. The technical college concerned will be responsible for the examination of candidates, subject to any general arrangements, including the approval of external examiners, which may be prescribed by the College of Technologists.

Exchange of Scientific Information

ASKED on November 5 about reciprocity between Great Britain and the United States of America and the U.S.S.R. for the exchange of scientific and educational and cultural information and personnel, Mr. Ian Harvey said there was complete reciprocity between Great Britain and the United States. The Soviet Government had refused a request from the British Government in April for talks on various aspects of freedom of information with a view of similar reciprocity between Britain and the U.S.S.R. Within a more limited sphere, however, reciprocal exchanges in the educational, cultural and scientific fields were arranged by the Soviet Relations Committee of the British Council, set up for this purpose in 1955 at the request of the British Government. The scale of these arrangements has increased in the past six months and reciprocal exchanges of scientific publications have recently been intensified.

Science Teachers and Laboratories

IN the House of Commons on November 6, the Minister of Education, Mr. Geoffrey Lloyd, stated that in March 1957 the heads of schools reported that they had about 500 vacancies for graduate teachers of science and mathematics, and that about 400 posts were unsatisfactorily filled. In a written answer, he stated that no arrangement has been made by his Department with the Industrial Fund for the Advancement of Science Education in Schools. The latter directs its attention to the independent and direct grant schools, because responsibility for the maintained schools rests with the local education authorities and his Department. The capital cost of new science laboratories being provided each year at maintained schools is now about £2 million.

Nuclear Installations (Licensing and Insurance) Bill

THE intention of the Nuclear Installations (Licensing and Insurance) Bill, which has recently been published, is to ensure that nuclear reactors on land

are made effectively subject to control in the interests of safety and that their owners make adequate provision for the payment of compensation should the need arise. The Government's intention to introduce legislation on these lines was announced in the House of Commons on February 10 by the Parliamentary Secretary to the Minister of Power. The operation of a nuclear reactor will require a licence from the Minister of Power (in Scotland the Secretary of State), and every licensee will have to pay compensation for any damage to property or personal injury from radioactive contamination even if it is due to an unavoidable accident, except to the extent that the claimant has been guilty of contributory negligence. The licensee will be required to insure his liability or show that he has adequate liquid assets. The liability is limited to £5 million in respect of any one incident. In the highly unlikely event of an incident causing more than £5 million worth of damage, special measures would be needed, and claims will be dealt with as Parliament determines. Since certain types of injury from radiation may become apparent only after a long time, the Bill provides that damages may be claimed up to ten years after the incident concerned. The U.K. Atomic Energy Authority already has a similar liability to that proposed in the Bill but it is not limited in amount; the Bill contains provision to extend the Authority's present liability to cover nuclear fuel in the course of carriage. The insurance market has informed the Government that it is ready to provide the necessary cover. Questions about premiums are a matter for the insurance market and the owners of reactors.

European Nuclear Energy Agency

In a pamphlet, "European Nuclear Energy Agency—Structure and Functions—First Joint Undertakings" (pp. 12. Paris: Organization for European Economic Co-operation, 1958), the Organization for European Economic Co-operation has issued what is largely a popular and illustrated version of the first report of the Steering Committee for Nuclear Energy. There are included some accounts of the organization of the Agency and the way in which it seeks to co-ordinate European scientific and technical activity in this field and to provide an overall view of research and investment programmes in nuclear energy in Europe, as a step towards harmonizing these programmes and avoiding duplication. Some account is also given of the stage reached in the construction of the nuclear study centre at Mol, where the small-scale joint plant for treating fuels from different reactors is to be built, of the boiling water reactor built at Halden by the Norwegian Institute for Atomic Energy and other projects of Eurochemic. There is also a map showing nuclear installations in member countries and a brief bibliography.

Civil Service Commissioners: Report for 1957–58

The ninety-second annual report of the Civil Service Commissioners, covering the period April 1, 1957–March 31, 1958 (pp. 32. London: H.M. Stationery Office, 1958. 2*s*. net), again refers to difficulties in recruitment and failure to meet all requirements; in most of the main classes of the Civil Service there were more vacancies than suitable candidates. During the year, 111,702 candidates were dealt with, compared with 112,590 in the previous year, but the number of successful candidates rose from 11,606 to 13,057 and the quality of applicants for the administrative class improved. There were thirty-nine successful candidates for forty vacancies, and it appears that the measures taken in recent years to make the work of the administrative class better known to university students have yielded results. The shortage of young trained scientists continued to affect recruitment to the scientific officer grade and more than half the vacancies advertised remained unfilled, although in the senior scientific officer competition most of the vacancies declared by departments were filled. Sixteen candidates of high promise were offered fellowships as a result of the Research Fellowship Competition, and, as a new departure, information about the 1958 Fellowship Competition was sent to British nationals at present holding Canadian and United States Fellowships. About seventy were willing to attend interviews which took place in Ottawa and Washington. Only thirty-six out of sixty-five declared vacancies for patent examiners were filled, and there was a decrease in applicants for vacancies in the engineering and technical classes. Recruitment of candidates with good scientific and technical qualifications into the Factory Inspectorate remained difficult. The continued lack of well-qualified young entrants for the engineering posts causes concern as to the future leadership in this field.

National Science Foundation Grants for Undergraduate Research

The U.S. National Science Foundation has announced plans to make a limited number of grants to colleges, universities and non-profit-making research institutions to provide, on an experimental basis, opportunities for undergraduates reading for degrees in the physical, biological, mathematical and engineering sciences to participate in research projects conducted by experienced scientific investigators. This scheme may operate either during the academic year or during the summer. Approximately 1,000 undergraduates at about one hundred institutions in the United States will be able to participate in these laboratory and field programmes which will afford them an opportunity to become acquainted with the nature and methods of research in progressively more independent roles. The Foundation will provide grants up to a maximum of 400 hr. per student. Expendable supplies and secretarial and administrative expenses directly attributable to this student training will also receive support.

Talanta: a Journal of Analytical Chemistry

The first issue of a new journal, *Talanta* (1, Nos. 1/2; July 1958. Pp. 196. Published bi-monthly. Subscription (including postage): 17 dollars a volume (Great Britain, 120*s*.); for subscribers certifying that the journal is for their own personal use, 15 dollars (Great Britain, 105*s*.). New York and London: Pergamon Press, 1958), has now been published, with Dr. C. L. Wilson, of the Queen's University, Belfast, as editor-in-chief, regional editors in the United States, Czechoslovakia and Japan, and an advisory board of chemists eminent in the field of analytical chemistry. The editors hope to expedite the publication of the results of research by publishing papers within three to four months of acceptance and short communications within thirty to sixty days. Papers can be submitted in English, French or German. The present double issue contains twenty-one research

papers, followed by short communications, book reviews, notices and lists of books and papers received.

Forum

A NEW educational journal has recently been launched with the view of discussing new trends in education with the appropriate title of *Forum*, and under the joint editorship of two lecturers in education at the University of Leicester, R. Pedley and B. Simon. Particularly concerned with the efforts to abolish the tripartite system of education in England and Wales, the first issue contains details of the present stage of the London plan to reorganize its secondary education in a system of comprehensive schools. There is also an account of the early stages of the Leicestershire experiment to eliminate the 'eleven-plus' examination, without bringing all children within a single comprehensive school. These will be followed in future issues by articles describing changes in other areas of Britain where some form of comprehensive education is taking place. The journal is also concerned with the efforts now being made in many junior schools to modify rigid streaming and with new developments in the secondary modern schools. There is also a symposium on "Science Teaching in the Nuclear Age" and an article by Dr. Robin Pedley assessing the educational programmes of the political parties. Provided that future issues of the journal will remain as free from political bias as the first, *Forum* should provide a valuable means of communicating new thoughts and developments in the realm of secondary education. Whether this courageous experiment can survive at its present price (3*s.* for single issues or 8*s.* 6*d.* for three issues in one year) must be a cause for concern. The journal is published from 71 Clarendon Park Road, Leicester.

Science in Six American States

A REPORT recently issued by the U.S. National Science Foundation, entitled "Scientific Activities in Six State Governments", summarizes the findings of a survey conducted in 1954 to determine expenditure and man-power involved in scientific activities in California, Connecticut, New Mexico, New York, North Carolina and Wisconsin. The study covered only State-supported activities, including research and development, collection of data, dissemination of scientific information, training of scientific manpower, and testing and standardization. Of the total expenditure of 68·9 million dollars reported, 57 million dollars were spent on research and development, and of the total 4,335 man-years, 3,831 were similarly devoted. Scientific activities in State universities and agricultural experimental stations accounted for just less than 70 per cent of the totals in both dollars and man-years. The proportion devoted to research and development was similar in all six States, and health, education, welfare, research development and public works accounted for 80 per cent of both funds and man-years. In all six States, the business, labour and vocational licensing agencies and the State universities tended to rely more heavily on Federal funds for their programmes of scientific activity than did other groups of agencies, and this is attributed directly to the high level of Federal participation in the employment security functions of State governments. Some reference is made to the character of State organization in the conduct of research and development, to interdepartmental machinery for co-ordinating programmes, as well as to the inter-State and Federal influence of such co-ordination.

Birds and Mammals of Canada

FOLLOWING many requests from visitors to the Museum, the Department of Northern Affairs and National Resources of the National Museum of Canada has published two attractive booklets describing many of the native birds and mammals. The first ("Quelques Oiseaux du Canada." Pp. 48. (14 planches.) Ottawa: Queen's Printer, 1957. 35 cents), written in French by W. E. Godfrey, describes the typical characteristics of a bird, the distribution and numbers of birds throughout Canada, song, territory and breeding cycles, migration routes, food and the relation of birds to man. This is supported by details of some of the better-known and less well-known birds of Canada. The second ("Canadian Mammals." Pp. 81. Ottawa: Queen's Printer, 1958. 50 cents), written in English by A. W. Cameron, describes most of the bigger mammals such as the harp seal, the finback, white whale and blackfish, as well as the smaller mammals like the cinereous shrew and the star-nosed mole. Each account includes details of the anatomy, ecology and breeding behaviours of the mammal as well as a clear and attractive black-and-white drawing by John Crosby. The birds have been similarly illustrated by the same artist.

Coastal Erosion

ONE of the principal preoccupations of students of coastal erosion is the way in which beach material moves under the influence of waves and currents. Until recently, it has not been possible to obtain direct evidence. In an article in the *Geographical Journal* (124, part 2, 210; June 1958) a method of marking pebbles with the radioactive isotope barium-140 – lanthanum-140 is described. It is possible, by searching the sea bed and beach with Geiger counters, to trace the movement of the marked pebbles. This has been done at Scolt Head, and the present paper, by C. Kidson, A. P. Carr and D. B. Smith, gives an account of its application to Orford Ness, the shingle spit at the mouth of the River Ore in Suffolk. During a period of six weeks a large number of contacts was obtained, and it was shown that beach material moves along shore under almost all conditions and in more than one direction. The direction of movement is principally determined by the winds prevailing at the time, and the general direction of longshore drift is that developed under the influence of the dominant wind. It was also shown that river mouths, even where flood and ebb tides are strong, do not form barriers to the movement of beach material.

Ga'actic Rotation

MORE than twenty years ago Plaskett and Pearce gave an authoritative discussion of the rotation of the galactic system, using material referring mostly to the northern section of the Milky Way and to distances less than one kiloparsec. During the past six years the lack of observations from the southern hemisphere has been remedied at the Radcliffe Observatory, Pretoria, where 350 velocities of early-type stars have been obtained. A new analysis of galactic rotation has been made by M. W. Feast and A. D. Thackeray, and their results have now been published (*Monthly*

Notices of the Royal Astronomical Society, **118**, 125, 1958). Their work was based on a selection of the available data, including only the more distant stars, for which the velocities should show galactic rotation effects. The rotation is usually described by the Oort constant A; the value of A has been the subject of some controversy. Analysing their data in several ways, Feast and Thackeray obtain for A the mean value $17{\cdot}5 \pm 1{\cdot}5$ km./sec./kiloparsec. The new results do not support the lower values of A obtained in some earlier determinations. Two partly independent methods were used to derive a value of the distance from the Sun to the galactic centre; the most probable value is 8·9 kiloparsecs. A value of 0·5 for the ratio of the axes of the velocity ellipsoid appears to be appropriate for distant B-type stars. The final section of the paper by Feast and Thackeray is devoted to a discussion of the variation of the angular velocity $\omega(R)$ of the Galaxy as a function of the distance R from the galactic centre. The results are in general agreement with the curve derived from Schmidt's model of the Galaxy, itself based on 21-cm. radio observations. $\omega''(R)$ definitely appears to be positive rather than negative. A negative value, obtained in some earlier investigations, is very unlikely on general dynamical grounds.

Australian Biochemical Society

The Australian Biochemical Society held its third annual general meeting in the Medical School, University of Adelaide, during August 18–20. At this meeting fifty-three papers were presented, and the second annual lecture of the Society was given by Mr. Hedley Marston, on "The Biochemical Function of Cobalt". The present membership is 280, and this year's president is Prof. R. K. Morton, of the Waite Institute, Adelaide. The honorary secretary is Dr. F. D. Collins, Department of Biochemistry, University of Melbourne.

Welsh Soils Discussion Group

Under the auspices of the Welsh Plant Breeding Station and the Departments of Agricultural Chemistry, Geography and Geology in the University College of Wales, Aberystwyth, a Soils Discussion Group has been formed, which held its first meeting on October 29. Some of the members of the Group are members of the British Society of Soil Science, which has recently lent its support to the formation of local groups to concentrate on soil studies in their local areas. Some thirty members attended the first meeting, including Dr. Alex Muir, director of the Soil Survey of England and Wales, and some members of the staff of the Departments of Agricultural Chemistry at the University College of North Wales, Bangor, of the Nature Conservancy (North Wales), of the Forestry Commission (Aberystwyth) and of the National Agricultural Advisory Service (Trawscoed). The first meeting was addressed by Dr. Nicholas Rast (Geology Department, Aberystwyth) on "Geochemistry in the Service of the Soil". The second meeting of the Group will be held in Aberystwyth at the Department of Geography on February 4, when Mr. James A. Taylor (Department of Geography) will lecture on "Slope, Climate and Soil". A third meeting will be held on April 22, when Dr. Rice Williams (Trawscoed) will introduce the subject "The Soils of the Aberystwyth Area". Further information can be obtained from J. A. Taylor, Department of Geography, University College of Wales, Aberystwyth.

U.S. National Research Council Conference on Fracture

The National Academy of Sciences – National Research Council is organizing a seminar on "The Atomic Mechanisms of Fracture" to be held in Cambridge, Massachusetts, during April 12–14, 1959, to discuss the following topics: theoretical aspects of fracture; cleavage; crystalline and non-crystalline fracture; fatigue and ductile fracture; high-temperature fracture. The conference is being sponsored jointly by the National Science Foundation, Office of Naval Research, Air Force Office of Scientific Research, and the National Academy of Sciences – National Research Council. Further information may be obtained from Dr. B. L. Averbach, chairman, or Dr. D. K. Felbeck, secretary, Conference on Fracture, National Academy of Sciences – National Research Council, Washington, D.C.

Announcements

Dr. M. L. M. Salgado, soil chemist and acting director, has been appointed permanent director of the Coconut Research Institute of Ceylon.

The following were recently elected to office in the Mineralogical Society: *President*, Prof. C. E. Tilley; *Vice-Presidents*, Prof. L. R. Wager and Dr. A. K. Wells; *Treasurer*, Prof. J. H. Taylor; *General Secretary*, Dr. G. F. Claringbull; *Foreign Secretary*, Dr. L. J. Spencer; *Editors of the Journal and Abstracts*, Dr. M. H. Hey and Dr. N. F. M. Henry.

The Geological Society of London has announced the award of R. H. Worth Prizes as follows: to Mr. E. W. J. Moore, in recognition of his work on the goniatite succession of the Carboniferous rocks of the north of England and Ireland; and to Mr. C. W. Wright, in recognition of his researches on the stratigraphy and faunas of the English Cretaceous rocks, and especially on the Cretaceous Ammonoidea.

An informal discussion on "Relaxation Processes" will be held under the auspices of the Faraday Society in the Department of Chemical Engineering of the Imperial College of Science and Technology on November 27. An introduction by Prof. A. R. Ubbelohde will be followed by contributions by Prof. C. J. F. Bottcher (Leyden) on dielectric relaxation; Dr. Vera Daniel (Electrical Research Association) on dielectric relaxation in crystals containing hydrogen bonds; Mr. W. Reddish (Imperial Chemical Industries, Ltd., Plastics Division) on relaxation in high polymers in the solid state; and Dr. J. Lamb (Imperial College) on ultrasonic relaxation in liquids. Further information can be obtained from Dr. J. C. McCoubrey, Department of Chemical Engineering, Imperial College of Science and Technology, London, S.W.7.

In *Nature* of October 18, p. 1060, the list of Waverley awards was printed; a special award was announced in the official list as being made to Mr. M. D. Lilley. This was incorrect; the award was made to Miss M. D. Lilley, of Aplin and Barrett, Ltd.

Erratum. In the communication "Removal of Gases in High Vacuum Systems by Metal Abrasion", by M. E. Haine, E. W. R. Francis and R. N. Bloomer in *Nature* of October 4, p. 931, par. 2, line 7, for "litres/μsec." read "litre microns per sec."; the 'litre micron' is a unit of quantity of a gas where the volume of the gas is in 'litres', the pressure of the gas is in 'microns' (10^{-3} mm. mercury).

ORIGINS AND PHILOSOPHY OF TECHNOLOGY

LARGE corporations both in the United States and Britain have recently been giving attention to the more metaphysical aspects of the power they embody or produce, and considering the direction of the steps they intend to take in the second half of the twentieth century. In the United States, General Motors employed Peter Drucker to sketch for them "The Concept of the Corporation". In Britain, from the periphery of an industrial conference, similar heart-searchings are visible. Perhaps the best description for this activity is Adolf Berle's "Matrix Work", which he defined as "tending towards a body of sophisticated thinking whose aim, properly organized, is a concept of a community making for the good life".

Big bites into the edges of this vast and important sphere of thinking have just been made by the Electricity Council. Its chairman, Sir Henry Self, is particularly well qualified to do so, for in the midst of a distinguished career at the Board of Trade, the Post Office, the Foreign Office, the War Office, the Air Ministry and the British Electricity Authority, he has found time to supplement his originally scientific training by separate academic qualifications in mathematics, divinity, classics and philosophy. Having ploughed, harrowed and sown such diverse fields, all in their way fertile, he has now been winnowing the harvest of a life-time. Moreover, as president of the Modern Churchman's Union he is particularly concerned with presenting in contemporary terms a teleology of the modern world. He sees the universe as a complex of experience in every conceivable form at any possible level. He cites the collect in the "Book of Common Prayer" that prays for the grace not only to "read, mark and learn" but also to "inwardly digest" that which is "written for our learning". His introduction to the eight lectures* which were delivered to an invited audience of members of the senior staff of the Electricity Supply Industry in the autumn of 1956 emphasizes the inward nature of this digestive process.

As an aperitif, he has assembled three well-known figures to present the fruits of their work on the history of science: Prof. H. Dingle, Prof. D. McKie and Dr. P. Dunsheath. Each takes two strands of human thought and development which has fundamental significance for an understanding of our times and which, in Sir Henry Self's view, can be used as "the basis for future development of twentieth century life". Prof. Dingle presents us with Galileo and the beginnings of modern science, Prof. McKie follows on with the Royal Society and the scientific academies, and of course Lavoisier and the beginnings of modern chemistry. Prof. Dingle returns with a lecture on the nineteenth century and the expansion of the physical sciences, and Dr. Dunsheath with two lectures on the engineer and human progress. Sir Henry Self has not only given the introductory and the concluding lecture but has also published a further booklet*, treating in a complementary way twentieth century science and its implications for modern thinking. In this he confines himself to the exact sciences, but promises us further supplements on biology, medicine and psychology.

To the philosopher these two booklets are interesting and significant in that they reveal Sir Henry as a disciple of that great scientific statesman, Viscount Haldane, to whom, as much as any man, we owe the foundation of the Department of Scientific and Industrial Research. For he sees society evolving through community, creative adventure and the pursuit of truth. He is concerned with the bipolar nature of man. As a twentieth century mystic in the tradition of Boehme, William Law and Coleridge (though he does not shelter behind their names) he says "we have got to try and break from the bad habit which has grown over seven centuries whereby we are so proud of our empirical development, of the idea of trial and error, experiment and test, that having developed that we have thrown away the origins, the sources, out of which it sprang". These origins and sources show man, not as a super-computor capable of grinding out thoughts, words and ideas with a brain and a nervous system, but a living embodiment of ideas which have enduring eternal value.

Texts are out of fashion. If one were to be put on the front of these two booklets it would be *Romans*, i, 20: "For the invisible things of him from the creation of the world are clearly seen, being understood by the things that are made".

W. H. G. ARMYTAGE

* "The History and Philosophy of Science and Technology". Pp. vi+139. 9*s*. (Education and Training Department of the Electricity Council, London, 1958.)

* Sir Henry Self, "Some Implications of Modern Science". Pp. ii+18. 1*s*. 6*d*. (Electricity Council, London, 1958.)

IONS OF THE TRANSITION ELEMENTS

A GENERAL discussion organized by the Faraday Society on "Ions of the Transition Elements" was held in Dublin during September 9–11. The main object was to consider the electronic structures and properties of these ions, particularly when included in complexes. A further object was to bring together physicists whose work was concerned with the structures of these ions and theoretical and experimental chemists whose interests lay in the same direction. It was most fortunate that both Prof. L. Pauling (California Institute of Technology) and Prof. J. H. Van Vleck (Harvard University) could be present, for their names are intimately connected with two of the most important theories that have been applied to the electronic structures of these compounds.

Two introductory papers at the beginning of the meeting were given by Dr. J. W. Linnett (University of Oxford) and Prof. M. H. L. Pryce (University of Bristol). The former surveyed the theories and experimental methods that have been employed, while the latter considered, in very general terms,

the special features of the electronic structures of these ions from the physicist's point of view.

The first session was devoted to four papers which dealt with optical absorption. The first, by Dr. W. P. Doyle and G. Lonergan (University College, Dublin), described some measurements on the transmission of radiation by films of cobaltous and nickelous oxides between 360 and 1,000 mμ thick. The first maxima for both were interpreted as exciton transitions. The results were discussed on the basis of crystal field theory. The next two papers both dealt with the absorption spectra of transition metal ions in lattices of Al_2O_3. Prof. Pryce and W. A. Runciman (Harwell) studied trivalent vanadium in corundum, while Dr. S. Sugano and Dr. Y. Tanabe (University of Tokyo) considered trivalent chromium in ruby. The former workers succeeded in resolving the fine structure of two absorption bands and then considered theoretically the energy-levels for two *d*-electrons in a trigonal field. Sugano and Tanabe reported on the Cr^{3+} line spectrum in ruby and also discussed its interpretation. Prof. H. Hartmann and H. Müller (University of Frankfort) measured the spectra of the hexa- and hepta-hydrates of nickel sulphate to compare with calculations that had been made on the $Ni(H_2O)_6^{2+}$ ion. The results satisfy the theoretical requirements. A splitting of the main bands, indicating a departure from octahedral symmetry, was observed. The discussion at this session was mainly concerned with the reasons why certain substances were very intensely coloured.

The next five papers dealt with the application of paramagnetic resonance spectroscopy to transition metal ions. Dr. J. Owen (University of Oxford) reviewed the use of electron- and also nuclear-resonance to measure electron transfer. He also considered superexchange between pairs of iridium ions in mixed crystals of $(NH_4)_2(Ir,Pt)Cl_6$ containing sufficient iridium to ensure the presence of enough pairs of iridium ions which were nearest neighbours, but which had no other iridium neighbours. Dr. W. Hayes (Argonne National Laboratory) had studied ions such as Cr^+ and Fe^+ contained in a sodium fluoride lattice and produced there by γ-rays, X-rays or electrons. The fluorine hyperfine structure was used to measure the amount of electron transfer to the fluorines. Prof. J. E. Wertz, J. H. E. Griffiths and J. W. Orton (University of Oxford) and P. Auzins (University of Minnesota) described experiments with single crystals of magnesium oxide which contain iron group impurities. Because of the high dilution and exact cubic symmetry the lines are very narrow and in some specimens 200 lines were observed. These spectra can be used to study lattice defects.

J. F. Gibson, Dr. D. J. E. Ingram and Dr. D. Schonland (University of Southampton) presented results for electron resonance measurements of ferri-hæmoglobin derivatives. A molecular-orbital treatment for these square-bond derivatives was given and the conclusions compared with the results for this and similar copper and cobalt complexes. Dr. J. S. Griffith (University of Cambridge) gave a theoretical treatment of the electronic structures of these complexes, his approach being a crystal field one. He examined his conclusions in relation to the electron resonance and magnetic susceptibility measurements.

The next two papers dealt with magnetic properties. Van Vleck discussed the magnetic anisotropy of crystals and the occurrence of inverted crystalline energy-levels. He concluded that, while the cubic part of the field is quite stable, the non-cubic part may be very dependent on the nature of the cation. Dr. B. N. Figgis, Dr. J. Lewis, Prof. R. S. Nyholm and R. D. Peacock (University College, London) measured the magnetic susceptibilities of some complexes of osmium, ruthenium, rhenium and iridium over a temperature range. The configurations de_t^3, de_t^4 and de_t^5 were involved. The results were discussed in terms of Kotani's theory.

Dr. C. K. Jorgensen (Technical University of Denmark, Copenhagen) discussed the decrease in repulsion between electrons in the *d*-shell of a complex ion compared with that in a free ion. The effect is due partly to an expansion of the *d*-orbitals because of increased screening and partly to their participation in covalent bonding. Prof. D. P. Craig and E. A. Magnusson (University College, London) also discussed this effect from a theoretical point of view and concluded that the effect could be largely explained without electron transfer into the 3*d* orbitals.

Dr. J. Chatt, L. A. Duncanson, B. L. Shaw (Imperial Chemical Industries, Welwyn) and L. M. Venanzi (University of Oxford) described measurements using infra-red spectra of the N—H vibration frequencies in various amine complexes. They discussed their results in terms of the extent and type of the electron drifts taking place. Dr. R. J. P. Williams (University of Oxford) showed that the stabilities of complexes cannot always be correlated with the ligand field-splitting factor. He concluded that stabilities should be related only to the ground-state properties and not to the excitation measured by the splitting factor.

Dr. L. E. Orgel (University of Cambridge) discussed the structure of a number of transition metal oxides, considering in particular distortions from a regular arrangement. He also examined the relation of this to the phenomenon of ferroelectricity. N. S. Hush (University of Bristol) presented graphs showing the variation in internuclear separation for the halides, oxides, etc., of the transition metals of the first long period. He also made calculations relating to these distances and contractions in them.

Dr. L. A. K. Staveley and T. Randall (University of Oxford) described measurements they had made of the heats of formation of a large number of complexes involving ethylenediamine tetraacetic acid. Combining their data with measurements of stability constants, they obtained entropy changes. The values were compared with one another and it was found that they fell into several sets. This was discussed. Dr. A. A. Vlcek (Academy of Sciences, Prague) described some work on polarographic half-wave potentials of a series of complexes and found that the potential could be correlated with the position of the ligands in the spectrochemical series. This and other results were then discussed in terms of the mechanism of the electrode process.

Throughout the meeting there was active discussion between the physicists and those chemists whose interests were definitely on the theoretical side or tended that way. But at times it did seem that there is still a great need for a better presentation of the theoretical ideas and nomenclature to the chemists whose activities are more largely experimental.

J. W. Linnett

THE CENTENARY OF 'DARWINISM'

THE Linnean Society has issued a special number of its journals in celebration of the centenary of the first publication of the theory of evolution by natural selection in the papers by Darwin and Wallace given to the Society in 1858*. The number contains thirteen papers, mostly by Fellows of the Society. Three of these deal with Darwin and the development of his theory during the intervening century, and the rest with modern work on evolution, five botanical and five zoological.

The first of the three contributions on Darwin's life and theory is Sir Julian Huxley's lecture on "The Emergence of Darwinism", which was given at the inaugural meeting of the fifteenth International Congress of Zoology last July. The lecture is an evaluation of Darwin's work in the light of our more recent knowledge. In particular, Huxley stresses the part of good fortune in Darwin's career, especially in providing him with the background required for his work. Even his delay in publishing his theory was fortunate, for the world was not ready for it earlier. So also was the intervention of Wallace, without which he might never have published, or, at least, not in the readable form in which it appeared. The lecture gave a most appropriate introduction to the Congress—as it also does to this publication—in emphasizing Darwin's outstanding quality as a biologist, not always sufficiently appreciated in modern times.

In his essay on Darwin's views on embryology and evolution, Sir Gavin de Beer discusses chiefly how far Darwin believed in Haeckel's theory of recapitulation. In the first edition of "The Origin" he was unwilling to accept the essential thesis of the theory, that life-histories evolve by addition of new stages at their ends, but he seems to have been persuaded by Fritz Müller and Haeckel to a still somewhat cautious acceptance, being in this matter led astray, perhaps because he realized that his knowledge of embryology was not wide. de Beer also believes that in at least one quotation Darwin anticipates the theory of pædomorphosis. This seems, to me, at least doubtful; the quotation can be read as doing no more than express doubts about the more extreme forms of the recapitulation theory.

In his article on "Darwin, Wallace and 'Pre-adaptation'", Dr. Harrison Matthews discusses the intellectual climate at the time of the publication of "The Origin", emphasizing, as did Sir Julian Huxley, the value to Darwin of the progress of thought in the preceding years and of the fact that in 1859—but not ten years earlier—younger men such as T. H. Huxley were available to support the new theory.

As a zoologist and not a botanist, I cannot discuss the botanical papers in detail. In his presidential address on fossil plants, Dr. Hamshaw Thomas gives an account of a great deal of recent work and shows that much evolution in plants has been by development of new structures rather than by modification of structures already present—the parts of the flower are not modified leaves. Dr. W. B. Turrill in his Hooker Lecture discusses the evolution of floras, with special reference to the Balkan peninsula; Dr. E. J. H. Corner has a paper on change of function in the organs of plants and the part it has played in evolution; Prof. I. Manton writes on chromosome numbers and the phylogeny of ferns; and Dr. Darnley Gibbs on the production of chemical substances in plants.

The longest of the zoological papers is Dr. S. M. Manton's summary of her work on locomotion in the arthropods. This will be useful to many who are not specialists in the subject and find her original papers longer than they can absorb. Prof. O. M. B. Bulman has an interesting paper on the evolution of colonial form in the graptolites, and Dr. E. B. Ford writes on the work of the Oxford zoologists on evolution in natural populations. In a paper on the problems of reptile classification, Mr. F. R. Parrington discusses much recent work and comes to the conclusion that there is no reason for thinking the reptiles diphyletic; all their groups are descended from primitive captorhinomorphs which were already reptiles. Finally, Dr. G. Pontecorvo writes on the versatility in evolution shown by the hereditary systems of organisms, both in typical holozygotic reproduction and in more primitive types.

Anyone interested in one or more of the many subjects dealt with in these papers will find something of value in this publication. It seems an excellent way to celebrate the centenary.

G. S. CARTER

* Darwin-Wallace Centenary. *J. Linn. Soc., Lond.* Botany, **56**, No. 365; Zoology, **44**, No. 205: pp. 1–152 (1958).

WATER FLUORIDATION AND DENTAL CARIES

THE Swedish Royal Medical Board has submitted a report to H.M. The King of Sweden concerning the use of fluorides in the prophylaxis of dental caries.

Swedish experts have been considering for a long time the prevention of dental caries by means of fluorides. In 1952 the Swedish Royal Medical Board appointed experts to study the question, and in 1955 the Board reported to the Swedish Government that the addition of fluorides to drinking water would be a valuable means of preventing the widespread dental caries; but the four members of the Scientific Council of the Board were doubtful about possible toxic effects of fluorides, even at the low concentrations present in drinking water, and the Board then preferred to await the outcome of further research. Meanwhile, it recommended the prohibition of fluoridation of public water supplies.

In 1957, however, a committee, consisting of Prof. Sven Sellman, Prof. Yngve Ericsson and Prof. Allan Strålfors, considered the prophylaxis of dental caries with emphasis on the use of fluorides for this purpose. This committee has presented, since 1958, more than one report. Members of the Scientific Council of the Royal Medical Board have also expressed their views.

There is general agreement that there are three principal methods of prophylaxis of dental caries, namely, administration of fluorides by vehicles other than water supplies, such as tablets, milk, common salt, flour and bone-meal, which the committee cannot recommend until further investigations have been made; topical application of fluoride to the teeth, which should, the committee thinks, be investigated clinically under the control of the Royal Medical Board; and fluoridation of the public water supplies.

With regard to this last method, the Board now reports that fluoridation of public water supplies does not involve any demonstrable hazards to health. It should, however, be carried out under strict control and care should be taken that, where it is instituted, the people are not exposed to fluorides derived from any other sources, such as foods or industrial gases. The Board reports that it has been found that a concentration of about 1 mgm. of fluoride per litre of water will reduce the incidence of dental caries by about 50 per cent in children and young persons who have consumed this water all their lives. In other children the caries will be reduced roughly in proportion to the period of consumption of the water. Fluoride also seems to protect the teeth of middle-aged people. A slight mottling of the enamel of the teeth appears in some children who have drunk water containing 1 mgm. of fluoride per litre during the period of tooth formation.

The technique of fluoridation of water is simple and has been thoroughly tested, but it is not applicable to those large groups of people in Sweden who have no access to a public water-supply. In Stockholm and Gothenburg the costs of fluoridation have been estimated at 0·3–0·4 Swedish crowns per person per year, or, when it is restricted to school children, 3–4 crowns per child per year. At present, expenditure on the public dental service for school children is about 75 crowns per child per year, and dental caries is so widespread that all available means of combating it must be used. In Sweden the city of Norrköping fluoridized one of its two public water supplies five years ago, and in Uppsala, Eskiltuna and Hälsingborg the public water supplies naturally contain more fluoride than is used for artificial fluoridation. The Board points out that in other countries in which fluoridation is used no evidence has been found that it harms health, and that both the American Medical Association and the World Health Organization have unreservedly recommended fluoridation as an effective and safe means of preventing dental caries.

The World Health Organization Expert Committee on Water Fluoridation, in its first report*, also concludes that drinking water containing about 1 p.p.m. fluoride has a marked preventive action on caries and does not impair health, and that controlled fluoridation of water is a practicable and effective public health measure.

G. Lapage

* World Health Organization. Technical Report Series, No. 146: Expert Committee on Water Fluoridation—First Report. Pp. 25. (Geneva: World Health Organization; London: H.M. Stationery Office, 1958.) 1 Swiss franc; 1s. 9d.; 0.30 dollars.

HOST — PARASITE RELATIONSHIPS

THE subject of host – parasite relationships covers such a wide field that the four papers on this subject, presented on September 3 in Section *M* (Agriculture) of the British Association meeting in Glasgow, not unexpectedly had comparatively little in common. Nevertheless, this diversity of interest helped to emphasize the fact that few living creatures escape the attention of some parasite or other, and that many specialized adaptations are necessary for parasitic life. Equally elaborate defence mechanisms have been evolved by potential hosts. The struggle for survival is governed very largely by the efficiency of these predatory or defending mechanisms.

Dr. J. A. Campbell (Moredun Institute, Edinburgh) explained that, among the insects, the true flies or Diptera apparently adopted the parasitic mode of life comparatively late in their evolutionary history. For this reason the flies show various degrees of adaptation to parasitism which can provide some information on the probable course of development of the habit. Morphological studies provide good evidence that the blood-sucking habit was evolved independently at different times in the various families. The behaviour patterns among the higher flies (Cyclorhapha) suggests that the course of evolution developed from generalized feeding on a wide variety of hosts to a more specialized association within a narrow range of hosts and even to complete dependence on a single species.

The stable fly (*Stomoxys calcitrans*), for example, feeds on a wide range of hosts, including man and most farm animals. Its larvæ can live in a variety of decomposing material, including dung heaps. The horn fly (*Lyperosia irritans*) is more specialized. The adults feed only on cattle, while the larvæ are confined to cattle dung. In the case of the sheep tick (*Melophagus ovinus*) dependence on a single host is complete. The fly has no wings, its larvæ are nourished *in utero*, and pupation occurs on the host.

There are many examples of the development of allergic sensitivity to insect bites. In some cases this can be recognized as a distinct clinical syndrome, such as Queensland itch in horses due to attacks of *Culicoides*. Insect saliva has been shown to be antigenic and the injection of this saliva can lead to the development of neutralizing antibodies in the host. So far as the hosts of blood-sucking flies are concerned, there is little doubt that for a variety of reasons some members of a species are more resistant to attack than others. There is no evidence, however, that specific immune reactions have any effect on the rate of infestation.

Dr. J. R. Norris (University of Glasgow) discussed the result of some recent work, largely done by two Canadian workers, Hannay and Angus, on the spore-bearing bacteria, *Bacillus thuringiensis*, which infect meal moth larvæ, and *Bacillus sotto*, which cause a septicæmic disease of silkworms.

Both organisms are capable of developing large protein crystals within their cytoplasm. If silkworm larvæ are fed with cultures of *B. sotto* containing both spores and protein crystals, they first become

paralysed and then develop a septicæmia as the bacteria penetrate into the body cavity. If the same culture is injected into the body cavity, the organisms multiply and produce a septicæmia but no paralysis occurs. The spores themselves are harmless if fed without the protein crystals, although they cause a septicæmia without paralysis if injected into the body cavity. The protein crystals can be extracted from the bacteria and cause paralysis and death if fed to the larvæ, but not if injected into the body cavity.

It seems, therefore, that the protein crystals are necessary for the penetration of the bacteria through the gut wall, and that the protein itself requires to be activated by the gut contents before it becomes toxic.

Dr. Norris also discussed the possible relationships between *B. cereus*, *B. thuringiensis*, *B. sotto* and *B. anthracis*. It is quite clear that there are a number of interesting problems to be solved in connexion with the pathogenicity of this group of organisms.

Dr. W. Mulligan (University of Glasgow) described the results of recent work on parasitic bronchitis of cattle which has been done at the University Veterinary School. This disease, caused by the lung worm *Dictyocaulus viviparus*, is responsible for serious debility among calves both in Britain and abroad. Severe attacks can be fatal. The disease may sometimes be cured by drugs which destroy the worm in the bronchi, but the treatment is usually too late to prevent severe damage to the lungs. Nevertheless, cattle gradually develop a satisfactory immunity after repeated exposure to natural infections. Dr. Mulligan and his colleagues have shown that calves can be protected against experimental infections of lung worms by injections of immune sera from animals which have recovered from the disease. This demonstration of the passive transfer of immunity has shown beyond all reasonable doubt that calves can produce protective antibodies against *Dictyocaulus viviparus*. The knowledge that circulating antibody can protect calves is of great value and a step forward in our understanding of the disease. Unfortunately, for practical reasons, this method of immunization cannot be used on the average farm. There is little doubt that the best method of prevention would be to find some means of artificially inducing an active immunity in otherwise susceptible animals. Attempts to immunize calves with various preparations of dead lung worms were apparently not very successful.

As natural infections gradually produce an active immunity, a trial was made with living vaccines consisting of larvæ which had been exposed to X-rays. It was hoped that larvæ treated in this way would survive for long enough in the calf to stimulate an active immunity and yet be incapable of causing progressive disease. Living vaccines of this type show great promise. It is thought that two doses of vaccine may give the best results, and an intensive trial is being made of this method. If these trials are successful, this vaccine should be of the greatest value to cattle owners in all parts of the world.

Dr. J. J. Bullen (Rowett Research Institute) discussed some of the factors which can influence the multiplication of pathogenic bacteria within a host. Examples were chosen from two experimental infections, enterotoxæmia of sheep and *Clostridium welchii* type *A* infections in embryonated hen's eggs.

The organism responsible for enterotoxæmia of sheep, *Cl. welchii* type *D*, is a normal inhabitant of the intestine. In certain circumstances, these bacteria multiply extremely rapidly and produce large quantities of toxin which is absorbed and kills the sheep. The disease cannot be reproduced in normal sheep fed on ordinary diets such as hay even if large numbers of *Cl. welchii* type *D* are introduced directly into the intestine. Viable counts of the bacteria in the living animal show that the bacteria cannot multiply fast enough to maintain their numbers and are soon removed by the normal flow of the intestinal contents. If the diet is suddenly changed, to wheat, for example, and the sheep overeats, the rumen becomes filled with undigested food. In the intestine this provides an ideal substrate for *Cl. welchii* type *D*. Very large numbers of the bacteria accumulate in the intestine. Large quantities of toxin are produced and the animal dies from acute enterotoxæmia. Thus, the diet of the sheep appears to play an important part in the development of this disease.

The experiments with eggs show that suitable antisera and, in certain circumstances, normal sera, can protect embryonated hen's eggs against normally fatal infections with *Cl. welchii* type *A*. The sera and bacteria are injected into the allantoic cavity. In unprotected eggs the organisms grow in the allantoic fluid and then invade the tissues of the embryo. In protected eggs the growth of the bacteria stops after an hour or two. There is no cellular response on the part of the host and no phagocytosis. Experiments of this kind appear to be useful for investigating the effect of sera on the growth of pathogenic organisms in the living host.

J. J. BULLEN

CHARGE-TRANSFER PROCESSES

A SYMPOSIUM on "Charge Transfer Processes", sponsored by the division of the Chemical Institute of Canada devoted to physical chemistry, was held during September 4–5 at the University of Toronto. The meeting, which had been organized under the chairmanship of Dr. B. E. Conway (University of Ottawa), was concerned with various aspects of the physical chemistry of reactions in which transfer of a formal charge occurs. Both homogeneous redox reactions and heterogeneous electrochemical reduction and oxidation processes were considered. About seventy-five physical chemists from the United States, Great Britain and Canada attended the academic sessions. Twenty-seven papers were presented, and each author was allowed ten minutes to describe the essential results of his work, all papers having been preprinted and circulated to participants several weeks before the meeting. About half the total time of the meeting was devoted to erudite and lively discussion of the papers presented. The meeting was honoured by the presence of a number of invited speakers from overseas, including Dr. D. J. G. Ives (Birkbeck College, London), Dr. J. E. B. Randles (University of Birmingham) and Dr. R. Parsons (University of Bristol). Prof. A. Frumkin (Academy of Sciences, Moscow), who had been invited, sent a paper for presentation but was regrettably unable to be present. On the

evening of September 4, participants at the symposium repaired to St. Michael's College for a reception and later took dinner at the Howard Ferguson Hall.

Prof. F. E. W. Wetmore (University of Toronto) opened the meeting by welcoming the participants. The first session, on "Homogeneous Processes", with Dr. B. E. Conway in the chair, was opened with a paper by Dr. H. Taube (University of Chicago) on bridging and simple ligand effects in electron transfer reactions; Dr. Taube discussed changes which took place in the inner and outer co-ordination spheres of ions when these ions underwent oxidation or reduction. This was followed by theoretical contributions by Dr. K. J. Laidler (University of Ottawa) on electron-transfer reactions in aqueous solutions, and by Dr. R. A. Marcus on electrochemical and chemical-electron transfers. In these papers the factors involved in the electron transfer process and the solvent redistribution which occurs upon the transfer of a charge were examined. In the paper by Dr. K. J. Laidler, repulsion effects which arise upon the approach of ferrous and ferric ions in aqueous solution were calculated quantitatively, allowing for dielectric saturation. Electron transfer occurs by tunnelling. An optimum free-energy barrier exists for which the rate constant has a maximum value. A free energy of activation in good agreement with that determined by experiment was deduced. The applicability of the Franck–Condon principle to these processes was discussed at length. Dr. J. Halpern (University of British Columbia) examined the applicability of the principle of equi-valence change to inorganic oxidation-reduction reactions in terms of the kinetic parameters of a number of selected redox reactions. Drs. I. H. Henderson, R. L. Haines, E. G. Lovering and E. J. Casey (Defence Research Board, Canada) presented data on the equivalent redox potential of aqueous solutions under γ-irradiation. The session on homogeneous processes was concluded with two papers on the mechanism of anomalous proton mobility in hydrogen-bonded systems. Dr. M. Kilpatrick (Illinois Institute of Technology) discussed the limiting conductance of lyonium and lyate ions with particular reference to some anomalous non-aqueous systems, and Dr. B. E. Conway, speaking on the role of proton tunnelling in certain charge transfer processes, described measurements on the conductance of heavy-ice and discussed the theoretical significance of the ratio of mobilities of hydrogen ions and deuterium ions in water, heavy-water and the corresponding ices, in terms of a proton-tunnelling mechanism. A theoretical examination of the possibility that proton tunnelling also occurred in certain electrode processes involving hydrogen was given and criteria for recognition of such an effect were presented.

The second session, with Dr. J. E. B. Randles in the chair, was devoted to the mechanism of cathodic electrochemical reactions. The mechanism of electrolytic silver deposition was discussed in a paper by Drs. W. Mehl and J. O'M. Bockris, who had used a galvanostatic technique. The results, together with certain theoretical considerations, led to the conclusion that surface migration of adsorbed silver atoms or 'partial ions' was the rate-determining process at low cathodic potentials, while ionic transfer from the double-layer to the surface was the slow step at higher potentials. Dr. C. V. King (New York University) discussed the kind of information that can be obtained from studies of exchange between metals and their ions in solution, and emphasized that care must be taken in the interpretation of exchange data owing to complications arising from bulk diffusion and other factors. The mechanism of growth of electrolytic metal whiskers was discussed in a paper by Dr. D. A. Vermilyea (General Electric Co.) in terms of the theory of crystal growth and the role of adsorbed inhibitors. Some abnormal hydrogen electrode reactions at gold were described by Dr. D. J. G. Ives (University of London) and a desorption reaction involving H_3^+ molecule-ions was discussed in an attempt to rationalize observations concerning reduction of tungstic oxide 'at a distance' from the electrode. Mr. A. Antoniu and Dr. F. E. W. Wetmore (University of Toronto) gave some further data on the hydrogen evolution reaction at silver. Inflected Tafel lines exhibiting slopes of 0·059 and 0·112 were observed as found in previous work, and the heats of activation ($\Delta H^{\ddagger}$) were determined for the two parts of the lines. A difference of about five kilocalories in $\Delta H^{\ddagger}$ for the two processes involved was deduced; a change of mechanism of the reaction with increasing cathodic potential was indicated. Experiments on transport of hydrogen through palladium-clad electrodes were described in a paper by Drs. S. Schuldiner and J. P. Hoare (U.S. Naval Research Laboratory). Diffusion was detected by measurement of the polarization built up on the non-polarized side of a diaphragm electrode. The effect of cladding other metals (iron, nickel, gold) with palladium was examined.

The third session, on September 5, with Dr. B. E. Conway in the chair, was concerned with electrochemical reductions other than those involving hydrogen or metal deposition. Dr. J. E. B. Randles discussed the determination of kinetic parameters of redox reactions from current–potential curves and by a.c. impedance methods and referred to experimental results on the V^{3+}/V^{2+} reaction at mercury electrodes. The two methods give similar results if appropriate calculation of concentration polarization effects is made. The mechanism of reduction of chloraquo–chromium-III ions in acid media, studied at the dropping mercury electrode, was discussed in a paper by Drs. H. Elving and B. Zemel (University of Michigan). At low acid concentrations a dual electron-transfer mechanism involving the electrode and chromium-II ions is suggested, while for $[CrCl_2.4H_2O]^+$ in 12 *M* hydrochloric acid a simple direct electron-transfer process is indicated. Dr. M. J. Allen (Ciba) described some problems in the study of organic electrochemical reductions.

A group of papers then followed on anodic processes. Dr. E. S. Snavely and N. Hackerman (University of Texas) described some analytical and coulombic studies on the anodic passivation of iron, and Dr. M. Cohen (National Research Council of Canada) discussed the formation and properties of passive films formed on iron under various conditions, for example, the presence or absence of oxygen or the presence of inhibiting ions. Some theoretical considerations on the mechanism of growth of anodic oxide films were presented by Dr. L. Young (British Columbia Research Council). Dr. B. E. Conway and P. L. Bourgault (University of Ottawa) described some studies on the kinetics of self-discharge of nickel – nickel oxide electrodes. The decay of electromotive force and rates of evolution of oxygen had been measured on open circuit over a wide range of concentrations of potassium hydroxide and the kinetics interpreted in terms of a scheme of consecutive reactions for rate-

determining oxygen evolution at anodic sites on the oxide.

The final session of the meeting, with Dr. S. Schuldiner in the chair, was concerned with the double-layer and adsorption at electrodes. The correlation between double-layer capacity and kinetics of electrode processes was examined in a paper by Drs. M. Breiter and P. Delahay (Louisiana State University), and Drs. R. S. Hansen and D. A. Hickson (Iowa State College) presented some interesting results on the apparent dependence on frequency of the capacity of the double-layer; relaxation times for water in the double-layer as high as 10^{-3} sec. were deduced. This occasioned some discussion, since it was pointed out that even in the ice lattice, where the water is strongly bound, the relaxation time is much smaller (about 10^{-6} sec.). Dr. R. Parsons (University of Bristol) read the paper by Prof. A. Frumkin (Academy of Sciences, Moscow) on the influence of surface-active anions on the electro-reduction of persulphate anions at negative potentials; the acceleration of the reduction of $S_2O_8^{2-}$ which was observed in the presence of surface-active anions was explained in terms of their effect on the potential (ψ_1) at the outer Helmholtz plane in the double-layer. Specific effects of cations on the kinetics required that a local fluctuating ψ_1-potential due to interaction of the adsorbed anions with cations in the double-layer be considered. A general thermodynamic analysis for the determination of heats of adsorption in ionic systems by electrocapillary studies was given in a paper by Dr. R. Parsons and results obtained for the isotensile heats of adsorption of potassium iodide at mercury were discussed. The meeting concluded with two papers describing the adsorption of hydrochloric acid and aromatic aminium salts at mercury by the electrocapillary method (Drs. E. Blomgren and J. O'M. Bockris, University of Pennsylvania) and the adsorption of methylene blue at mercury by collecting a large number of mercury drops which had fallen through the solution and analysing for the dye carried down in the double-layers of the drops (Drs. J. M. Los and C. K. Tompkins, University of New Brunswick). Some results from studies on the direct determination of adsorption of organic ions at solid metals were presented by Dr. B. E. Conway and Mr. R. G. Barradas in discussion.

Most of the papers presented at the meeting will be published early in 1959 in the *Canadian Journal of Chemistry*.

B. E. Conway

EAST MALLING RESEARCH STATION

ANNUAL REPORT

THE annual report of East Malling Research Station for 1957* contains some important research findings. A new semi-dwarfing apple rootstock, *M* 26, is described by W. S. Rogers; it is intermediate in vigour between *M* IX and *M* VII, and so fills a unique place. The elimination of virus from strawberry clones by heat therapy increased the fruit yield of several varieties, though the crop ripened later, and was more prone to *Botrytis* rot than untreated plants. In Early Cambridge and Rearguard, however, there was excessive vigour and a decrease in yield (W. S. Rogers and Muriel G. Fromow). Rooting and growth of root cuttings from the apple rootstock Crab *C* declined with increasing age of establishment of the parent plant, according to results obtained by R. J. Garner and E. S. J. Hatcher. Raspberry breeding work, by R. L. Knight and Elizabeth Keep, is now mainly concerned with the introduction of resistance to the virus vector *Amphorophora rubi* and to cane spot and *Botrytis*, while interspecific hybrids are being sought between black-currant and gooseberry. The apple breeding work of H. M. Tydeman shows progress towards a late-flowering variety which will be resistant to scab and mildew.

Two papers in the physiological section show that, in the British climate, temperature is perhaps the most important factor in fruit growth. C. R. Hancock and H. W. B. Barlow show that growth-rate of Crab *C* shoots was related to temperature and day-length, though the final internode length was less dependent on temperature and had little relation with the daily period of light. The same authors found that the effects on leaf growth of a summer gale in 1956 were mainly due to the fall in temperature. D. H. Maggs has compared growth of the rootstocks *M* II and *M* XVI with differences in time of leaf-break eliminated; the former produced more stem and the latter more root for plants of the same weight. *M* II had a smaller increase in weight produced per gram of leaf than *M* XVI.

Symptoms of magnesium deficiency in apple rootstocks can best be eliminated by foliar spraying with Epsom salts. Elsie M. Ford shows that this method is better than soil application and that it is not enough merely to remove the symptoms, for three sprays are necessary to bring increased vigour.

The virus disease known as little cherry causes serious damage in North America, and now A. F. Posnette and R. Cropley have reported it in Great Britain. G. W. F. Sewell and J. F. Wilson report another new trouble in that some common hop garden weeds have been found susceptible to the 'progressive' strain of the hop wilt fungus *Verticillium albo-atrum*. There were earlier indications that the hop virus 'nettlehead' was in some way linked with nickel content of the plant. J. T. Legg and P. J. Ormerod find that the symptoms of nickel toxicity and of nettlehead are distinct, though presence of the virus is associated with higher contents of some heavy metals than are found in healthy plants. R. S. Pitcher shows that the life cycle of the currant leaf midge *Dasyneura tetensi* varies considerably from year to year. This brings difficulties of timing control measures and demonstrates the necessity for more persistent toxicants. A study of *Blepharidopterus angulatus* by R. C. Muir is mainly an evaluation of the capture–recapture method of estimating orchard insect populations. Phytotoxicity studies by A. H. M. Kirby and Margery Bennett show that a number of

* Kent Incorporated Society for Promoting Experiments in Horticulture. Annual Report of East Malling Research Station, 1st October, 1956, to 30th September, 1957. (Forty-fifth year.) Pp. xxv+173. (East Malling, Maidstone: East Malling Research Station, 1958.) 17*s.* 6*d.*; 2.50 dollars.

acaricides are safe to use on the varieties of black currant and plum used for test. On the other hand, phenyl mercury chloride caused direct damage to pears in each season, irrespective of weather conditions.

The report contains the text of the Amos Memorial Lecture by F. C. Bawden on viruses and virus diseases —a most useful general review. It has also papers on methods of recording, sampling and experiment. There is a detailed paper on soil management effects on a number of chemical and physical properties of the soil (J. E. Goode and G. C. White) the practical implications of which are discussed in one of the four bulletins for fruitgrowers. A review, however, should lay a train of anticipation leading to the detail of the report itself. It is a current guide to the enlarging horizon of the application of science to the culture of fruit.

NEW HYDROXYAMINO-ACIDS IN PLANTS AND THEIR IDENTIFICATION

Hydroxyvaline in *Kalanchoe daigremontiana*

THE first application of two-directional paper chromatography to the investigation of soluble nitrogen compounds in plants was reported in *Nature* in 1947[1], and paved the way for the recognition of many new free amino-compounds in plants. By the application of the new techniques, the list of naturally occurring amino-acids became rapidly extended, for hitherto the emphasis had been upon the demonstration, in the free state, of the protein amino-acids and of the amides, asparagine and glutamine. The course of these discoveries has been summarized in a series of reviews[2] which show the unexpected range of structure which natural amino- and imino-acids display.

The hydroxyamino-acids represent a special category of compounds which have been largely revealed by chromatographic methods, and, as will be seen, the final identification of these substances presents special difficulties and problems.

Prior to the development of paper chromatography, serine and threonine were the only non-phenolic hydroxyamino-acids known with certainty to occur widely distributed and free in Nature. Hydroxyproline and a hydroxylysine of uncertain structure were known in collagen but not known free in plants. Reports of the presence of β-hydroxyvaline[3] and β-hydroxyglutamic acid[4] remained unconfirmed and eventually proved to be erroneous[5]. Since the application of chromatographic methods, the following hydroxyamino-acids have been found in plants: allohydroxy-L-proline[6]; hydroxy, methylproline[7]; 5-hydroxypipecolic acid[8]; 4 (or 3)-hydroxypipecolic acid[9]; homoserine[10]; γ-hydroxyglutamic acid[11]; dihydroxyglutamic acid[12]; γ-hydroxy, γ-methylglutamic acid[8c]; α-amino, γ-hydroxypimelic acid[13]; and α,ε-diamino, β-hydroxypimelic acid (tabtoxinine)[14]. However, only in the case of allohydroxy-L-proline[6] has the evidence for these new amino-acids been brought to completion by the synthesis of the compound in question followed by the resolution of the appropriate stereoisomer and the critical comparison, by appropriate physical and chemical methods, of the natural and synthetic products. In one difficult case, involving three centres of asymmetry, the amino-acid in question (tabtoxinine) on synthesis[15] was found to have a structure different from that first assigned (Braun, A., private communication). The final identification of new compounds with one or more centres of asymmetry, therefore, should include their stereoisomeric configuration; and this being so, more readily applicable methods of optical resolution are needed so that the final identification of these new substances need not lag so far behind their recognition as at present.

Information in both parts of this contribution will extend the general recognition of compounds of this type to include γ-hydroxyvaline and O-acetylhomoserine.

Hydroxyvaline was first recognized as an unidentified, ninhydrin-reactive spot on paper chromatograms of an alcohol-soluble extract of crowngall tumours from *Kalanchoe daigremontiana*[16] and was described as 'Unknown No. 75' in a review[2b]. Subsequent studies showed it to be present in leaves and stems also, but, as yet, only in this single species of *Kalanchoe*. The substance is not found in *K. beharensis*, *longiflora*, *sexangularis*, *marmorata*, *tomentosa*, *verticillata*, *gastonis-bonieri* or *pinnata*, nor has it been detected in the many other species of plants which have been examined in this laboratory chromatographically.

On hydrolysis of crude extracts, unknown[2] 75 partially disappears with the concurrent appearance of a second unknown, No. 78, and glutamic acid. The position of Nos. 75 and 78 on a chromatogram are shown in Fig. 1. This preliminary result was first interpreted to mean that two unknown amino-acids occupied identical positions on the chromatograms, and that only unknown No. 75 broke down to give No. 78, while the acid-stable material in the same position as No. 75 was assigned the number 76.

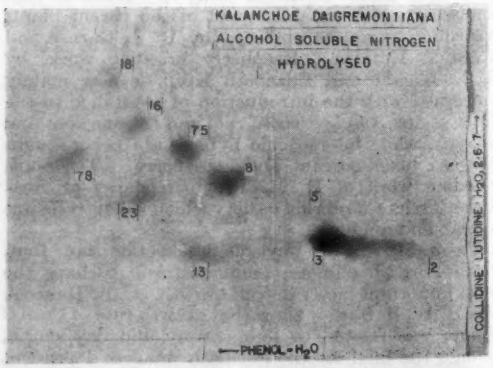

Fig. 1. Two-directional chromatogram, treated with ninhydrin, of the soluble compounds of *Kalanchoe daigremontiana* (copied from an original photograph in colour).
Numbered key to amino-acids: 2, aspartic acid; 3, glutamic acid; 5, glycine; 8, alanine; 13, arginine; 16, valine; 18, leucines; 23, γ-aminobutyric acid; 75 and 78, γ-hydroxyvaline and its lactone, respectively. (Nos. 75 and 78 react violet with ninhydrin)

Because of a general interest in glutamyl compounds[17], an attempt was made to isolate No. 75 and to determine its relationship to Nos. 76, 78 and to glutamic acid. An alcoholic extract from 60 gm. of lyophilized crowngall tumours of *Kalanchoe daigremontiana* was fractionated on 'Dowex'-50 × 4 after the methods of Partridge and Brimley[18]. Unknown No. 75 came off the column with the neutral amino-acids, whereas Nos. 76 and 78 came off the column with the bases, in fact, even slightly after arginine. In the ammoniacal eluate, No. 78 rapidly disappeared with the appearance of more of No. 76. Since several fractions then contained pure 76, it was easily shown that No. 76 was largely converted to No. 78 on acid hydrolysis and that ammonia hydrolysis reconverted No. 78 completely to No. 76. This tentatively identified No. 78 as a lactone with basic properties, produced by acid hydrolysis from the neutral hydroxyamino-acid, No. 76. Furthermore, unknowns Nos. 75 and 76 were not distinct but identical, and any confusion between them arose from the position of the equilibrium attained during acid hydrolysis, an equilibrium largely in favour of the lactone (No. 78) but with enough of the free amino-acid remaining to give the erroneous impression on chromatograms that a mixture of a stable and an unstable compound was involved. The appearance of glutamic acid on hydrolysis of the crude extracts is thus shown to be independent of the destruction of No. 75, and must arise from some other, still unidentified, source.

Having isolated No. 75 in the general manner indicated, an elemental analysis corresponded to the formula $C_{4\cdot97}H_{11\cdot33}NO_{3\cdot03}$ or $C_5H_{11}NO_3$; this could then be a hydroxyvaline. The Crumpler and Dent[19] test indicated an α-position for the amino-group and the ease of formation of lactone requires a γ- or δ-position for the hydroxy-group. Of the various compounds which would fit these requirements, α-amino, γ-hydroxy-*n*-valeric acid and α-amino-δ-hydroxy-*n*-valeric acid were obtained and shown to be readily separable from No. 75 on paper chromatograms, as was β-hydroxyvaline. The other two possibilities, namely, α-methylhomoserine and N-methylhomoserine, have not been obtained; however, neither α-methylamino-acids nor N-methyl amino-acids react quickly to give the typical violet colour with ninhydrin as does No. 75, and on this basis these two possibilities may also be tentatively eliminated.

At this point, all the indications were that No. 75 was γ-hydroxyvaline of unspecified stereochemical configuration, but this compound had never been synthesized and was unavailable for comparison. A new synthesis was required. One of us (E. S.) then prepared γ-hydroxyvaline by amination of α-chloro, β-methyl, γ-butyrolactone as follows.

The α-chloro, β-methyl, γ-butyrolactone was prepared by a modification of the method of Fleck and Shinz[20], hydrogenating α-keto, β-methyl, γ-butyrolactone in absolute ethanol with palladium-on-charcoal catalyst. The resulting α-hydroxy compound was converted to the α-chloro compound by refluxing with thionyl chloride in pyridine. This in turn was aminated in concentrated aqueous ammonia containing ammonium carbonate at 60° C. in a pressure flask for four days. This reaction mixture was passed over 'Dowex'-50 × 4, on which the amino-acid was retained and from which it was eluted with *N* ammonia. The product crystallized from the concentrated, syrupy eluate on addition of absolute ethanol, and after three recrystallizations showed a melting point of 209–11° C. (corrected). Elemental analysis gave C, 45·50; H, 8·25; N, 9·64; calculated: C, 45·11; H, 8·32; N, 10·5. Only the nitrogen value differed significantly from the calculated value.

Since the synthetic product and its lactone corresponded exactly with Nos. 75 and 78, respectively, on paper chromatograms in phenol – water, in butanol – acetic acid – water, and in collidine – lutidine – water, and because of the chemical evidence available, these two unknowns are now recognized as γ-hydroxyvaline and its lactone. Attempts to confirm this by reduction of natural γ-hydroxyvaline to valine with red phosphorus and hydriodic acid failed, only the lactone being formed in the treatment. Comparison of the infra-red absorption curves and the melting points of the synthetic and natural preparations showed differences, as would be expected since such comparisons are being made between a racemate which may contain both diastereoisomers and an optically active substance which is presumably a single stereoisomer.

The recognition of No. 75 as γ-hydroxyvaline now makes its isolation relatively easy. An extract of 128 gm. of lyophilized crowngall tumours from *K. daigremontiana* was evaporated to remove ethanol and was partitioned between water and chloroform to remove pigments. The aqueous layer was made acid (1 *N*) with hydrochloric acid and hydrolysed in the autoclave for an hour to form the lactone. The hydrolysate was filtered, evaporated to remove excess hydrochloric acid and then passed through an excess of 'Dowex'-50 in the ammonium form. Since the resin in this state retains only bases, the basic lactone, along with arginine and lysine, is retained. The column is eluted with 2 *N* ammonia and washed with water, then the eluate, boiled to hydrolyse the lactone and remove ammonia, is passed again through the same column. Again the bases are retained, but the γ-hydroxyvaline, now present as the neutral amino-acid, passes through and may be collected free of contaminating amino-acids. Following this procedure, 186 mgm. of crude product (melting at 215° C.) yielded 146 mgm. of recrystallized product (melting point 228° C.). A second crystalline form, decomposing at 248° C., may also be obtained under certain conditions. The pure product showed a specific optical rotation of (+) 10 deg. ± 0·5 deg. in water at 20° C.

Unknown No. 75 is therefore recognized as (+) γ-hydroxyvaline, but final and complete determination of structure awaits comparison with the optically active synthetic stereoisomers; in this respect, γ-hydroxyvaline presents the same problem as other new hydroxyamino-acids mentioned above.

J. K. Pollard
E. Sondheimer*
F. C. Steward

Department of Botany,
Cornell University,
Ithaca, New York,
and
Department of Food Science and Technology,
New York Agricultural Experimental Station,
Geneva, New York.

* Present address: State University College of Forestry, Syracuse University, Syracuse 10, New York.

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O-acetylhomoserine in *Pisum*

HOMOSERINE is now known to occur somewhat abundantly in the vegetative parts of pea plants[1,2], in which it is supposed to arise from aspartic acid[3], though it is said to be absent from the seed[2].

During the chromatographic examination of alcoholic extracts of the various organs of the plant, namely, leaf, stem, root and fruit, the presence of a substance reactive to ninhydrin but unstable in acid was noted. This substance proved to be present most abundantly in the pea pod, that is, the pericarp, of this leguminous fruit. It disappeared when the extracts were subjected to mild acid or alkaline hydrolysis. The then unidentified substance was referred to by Grobbelaar[4] as unidentified substance No. 200, and by Steward, Zacharius and Pollard[4] in their summary of the new nitrogenous constituents of plants as No. 84.

The relative positions of this substance, and of homoserine, known to occur in *Pisum*, on chromatograms, are shown in Fig. 1. When the lactone of homoserine is also present, as when homoserine is treated with acid, it appears as a diffuse 'streak' moving faster than homoserine in the phenol direction. The instability in acid of the unidentified substance, and the fact that it yielded, on hydrolysis, only one ninhydrin-reactive substance (homoserine), led to the first recognition of this substance as a derivative of homoserine, other than the lactone.

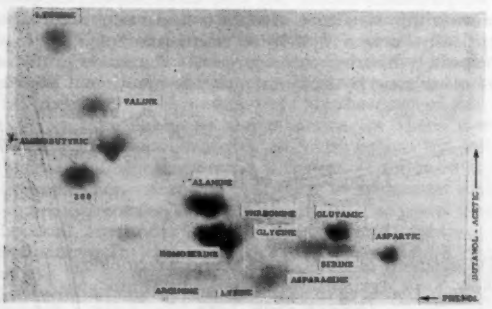


Fig. 1. Two-directional chromatogram, treated with ninhydrin, of the alcohol-soluble nitrogen compounds of *Pisum sativum* (copied from original photograph in colour)
No. 200 is O-acetylhomoserine, reacts violet. Under the conditions used, serine and glycine, asparagine and lysine were distinguishable by their colour reactions. Certain weak unlabelled spots are not positively identified

While a small amount of the substance in question was obtained from alcoholic extracts of pea shoots by paper chromatographic methods of Mueller[6], 35 mgm. of crystalline material were obtained from an extract made of the pea pods, from 4·5 kgm. of commercial peas. After clarifying the extract with basic lead acetate, lead was removed by hydrogen sulphide and the extract was evaporated at room temperature. The crystalline product was separated from the other constituents of the extract by the general method of Hirs, Moore and Stein[7]. Other attempted procedures of fractionation and isolation (absorption of the amino-acids on basic or acidic resins with the subsequent use of the appropriate eluting agent) failed, either because they were ineffective in separation or because this labile substance was decomposed. The procedure finally adopted was as follows.

The clarified pea extract was fractionated on a 15-cm. 'Dowex'-50 column, and the unknown substance emerged along with the neutral and acidic amino-acids. The acidic amino-acids were removed from the mixture, using an '*IR*-4*B*' column. Further successive treatments of the mixture on 'Dowex'-50 columns led to a final product contaminated only with some threonine, serine and proline. The final purification was accomplished on a cellulose-powder column (7 cm. × 65 cm.) by chromatography with *N*-butanol, acetic acid and water (9 : 1 : 2·9 by volume). The desired substance emerged from the column only slightly contaminated with proline. All the fractions which contained the substance desired were concentrated under reduced pressure at room temperature, yielding a small residue of yellowish substance. On solution in water, a waxy, insoluble, ninhydrin-negative material was discarded. The yellow aqueous solution was treated with activated charcoal, filtered through 'Celite', and the nearly colourless filtrate was concentrated *in vacuo*. By addition, drop by drop, of absolute ethanol, crystallization started and continued at low temperatures, and finally, by the addition of an excess of ether, 35 mgm. of crystals were obtained, washed with ether and dried over calcium chloride.

Despite the slight contamination with proline, evident even in the crystalline material, the elementary analysis corresponded to an acetylhomoserine (found C, 45·01; H, 6·80; N, 8·90; calculated for $C_6H_{11}NO_4$, C, 44·71; H, 6·88; N, 8·69 per cent).

Since the analysis does not distinguish between the N-acetyl derivative and the O-acetyl derivative of homoserine, both these substances were prepared from DL-homoserine. The methods adopted for these syntheses were as follows.

O-acetylhomoserine was unequivocally synthesized from an authentic sample of DL-homoserine by the method of Sakami and Toennies[8], as, in fact, Matsuo, Rothstein and Greenberg[9] have also reported.

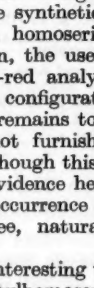
For the preparation of the N-acetylhomoserine, the method of du Vigneaud *et al.*[10] was employed. Neither the N-acetylhomoserine so synthesized nor any other N-acetyl amino-acids tried (glycine, alanine, methionine and valine) reacted with nin-

hydrin on paper. This eliminated any possibility that the natural product was the N-acetyl compound.

In addition to the elementary analysis, the identification of the amino-acid in pea plants as O-acetylhomoserine then follows from the following chromatographic evidence in phenol and butanol–acetic solvents: (1) the product as isolated was identical with that present in the crude extract of peas; (2) the isolated and synthetic products behave identically on chromatograms and toward ninhydrin; (3) the hydrolytic products in acid and alkali obtained from the synthetic and isolated substances also behave identically on chromatograms and toward ninhydrin, and these are recognizable as homoserine and, in acid solution, its lactone which, in turn, were also tested chromatographically in other solvents (collidine–lutidine; pyridine–toluene).

As in the other cases referred to in the preceding communication, there still remains the problem of the final stereoisomeric configuration of the natural substance. Until the synthetic product is resolved, or is prepared from homoserine of known stereoisomeric configuration, the use of physical methods of comparison (infra-red analysis, etc.) is not conclusive. In fact, the configuration of natural homoserine in plants still remains to be established, since this evidence was not furnished in the paper by Miettinen *et al.*[1]. Although this final step remains to be carried out, the evidence here reported nevertheless establishes the occurrence of an O-acetylhomoserine as a new, free, natural substance in pea plants.

To conclude, it is interesting to note the structural relations between acetylhomoserine and certain other natural compounds which can be treated as substituted C4 amino-acids. All these contain the structure



where R has the structure indicated in the compounds named below:

(*a*) if R is CH_3 the compound is γ-aminobutyric acid;
(*b*) if R is $CH_2.OH$ the compound is homoserine;
(*c*) if R is CHO the compound is aspartic-β-semi-aldehyde;
(*d*) if R is COOH the compound is aspartic acid;
(*e*) if R is $CH_2.NH_2$ the compound is α,γ-diamino-butyric acid;
(*f*) if R is CH_2OAc. the compound is O-acetylhomoserine;
(*g*) if R is $CH_2O.NH.CNH.NH_2$ the compound is canavanine;
(*h*) if R is CH_2ONH_2 the compound is canaline.

A similar series of compounds can be visualized in the next higher homologues; of these, however, only the members corresponding to the following possibilities are well known, namely: (*c*) = glutamic semi-aldehyde; (*d*) = glutamic acid; (*e*) = ornithine; and for these three the metabolic inter-relationships are well worked out, with proline being the related cyclic compound. In the C4 series, azetidine-2-carboxylic acid now appears as the cyclic compound which bears a similar relationship to the appropriate members of the C4 series,[1].

It is interesting also to note that the substance γ-hydroxyvaline of the preceding communication differs from homoserine only by a methyl substitution or the β-carbon.

N. Grobbelaar
F. C. Steward

Plant Physiological Research Institute,
University of Pretoria,
South Africa,
and
Department of Botany,
Cornell University,
Ithaca, New York.

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AUXINS AND THEIR EFFECT ON THE GROWTH OF UNICELLULAR ALGAE

Effect of Ethanol and Auxins on the Growth of Unicellular Algae

THE effect of auxins on unicellular algae has been the subject of numerous papers, but many of the reported findings contradict each other as to whether and how the auxins affect these organisms[1–3]. We re-examined this problem because algae, if they responded to auxin, would be ideal organisms for the study of the biochemical basis of this stimulation. Some of the earlier observations may be explained by the present communication, in which we report a stimulation of growth by ethanol in several unicellular algae.

Chlorella vulgaris (*A.T.C.C.* 11468) was cultured at *p*H 6 in medium I of Hutner *et al.*[4] with a ten-fold increase in sodium dihydrogen phosphate and the addition of 1·2 gm. per litre potassium nitrate. Growth assays were conducted essentially as described by Hutner *et al.*[5]. Growth was estimated by measuring the optical density of the cultures at 440 mμ in a Klett–Summerson colorimeter, since preliminary experiments had shown a linear relation between optical density and cell counts carried out with a hæmocytometer. Carbon analyses were carried out by oxidation in potassium dichromate–sulphuric acid and measurement of the absorption at 440 mμ. A

Table 1. The Effect of Addition of Ethanol on the Growth of *C. vulgaris*

Parts of alcohol added, v/v	Optical density, 440 mμ	Sum	Range
None	110, 111, 104	325	7
$1:5\times10^{6}$	127, 112, 107	346	20
$1:10^{5}$	121, 120, 113	354	8
$1:5\times10^{4}$	137, 122, 142	401	20
$1:10^{4}$	186, 183, 166	535	20
$1:5\times10^{3}$	104, 100, 135	339	31
$1:10^{3}$	10, 12, 12	34	2
Sum of ranges			108

Factor for 5 per cent risk = 0·70; 108 × 0·70 = 74

Table 2. The Effect of Addition of 1 : 10,000 parts Alcohol (v/v) on the Carbon Content of *C. vulgaris* Cells

The amount of alcohol added equals 0·4 mgm. carbon per flask

No addition	mgm. carbon found in cells per flask 0·27, 0·40, 0·34, 0·34	Sum 1·35	Range 0·13	Average 0·34
1 : 10,000 alcohol	0·62, 0·48, 0·66, 0·57	2·33	0·14	0·58
Sum of ranges			0·27	

Factor for 5 per cent risk = 1·63; 1·63 × 0·27 = 0·44.

dichromate solution which had been completely reduced with sodium sulphite served as a blank. The difference in absorption of the sample from that of unreduced dichromate solution is a linear function of the carbon content. Statistical analysis was carried out by Link and Wallace's method of allowances.

Table 1 shows the effect of very small ethanol concentrations on the growth of *C. vulgaris*. An approximately two-fold stimulation of growth is observed. Since this stimulation occurred at extremely low ethanol concentrations, it was of interest to establish whether the stimulation was due to the utilization of the ethanol as a carbon source by the cells. Table 2 describes the results of an experiment in which the carbon content of the cells from media containing ethanol is compared with that of cells grown with no added carbon sources. It can be seen that the gain in carbon content can be accounted for from the amount of carbon added in the ethanol. The fact that such small concentrations of ethanol have such a marked growth-stimulatory effect can be explained if it is realized that carbon dioxide is the growth limiting factor under the assay conditions in most of the earlier experiments. When this limitation is removed, as, for example, by placing the cultures on a shaking apparatus, the stimulatory action of ethanol is lost. As could be expected, low concentrations of ethanol also stimulated the respiration of *Chlorella* when measured in a Warburg apparatus in the dark.

Recently, several reports have appeared[6,7] which describe beneficial effects of low concentrations of ethanol in higher plant systems which were being used for auxin studies. In our system no stimulatory effect could be found in the presence or absence of added ethanol, using a number of different auxins and anti auxins at concentrations from 10^{-7} to 10^{-4} *M*. Similar results were observed in experiments using *Euglena gracilis* strain z, *Coccomyxa simplex* (*A.T.C.C.* 11471), *Chlorella pyrenoidosa* (*A.T.C.C.* 11469), *C. ellipsoidea* (*A.T.C.C.* 11466) and *Scenedesmus obliquus* (*A.T.C.C.* 11457).

Many of the earlier papers on the effect of auxins on algae did not specify how the auxin solutions were prepared, and the possibility that ethanol was used cannot be excluded. Brannon and Bartsch[8] used alcoholic solutions upon the advice of Dr. Zimmermann, one of the early authorities in the growth-substance field, and their results very closely resemble those presented in Table 1.

Further work now in progress will attempt to define experimental conditions under which the stimulation of algal cell division would be sufficiently large to afford the use of this system for biochemical studies.

We wish to acknowledge the able technical assistance of Miss Barbara A. Edwards.

M. K. Bach
J. Fellig

Research Department,
Union Carbide Chemicals Co.,
South Charleston, West Virginia.
July 25.

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Ethanol as a Carbon Source for the Growth of *Chlorella vulgaris*

During studies of the effect of β-indolylacetic acid on the growth of *Chlorella vulgaris*, Brannon No. 1, cultured in darkness at 25° C., evidence has been obtained that ethanol is active as a substrate for the heterotrophic growth of this organism. β-Indolylacetic acid was incorporated in certain experiments by the use of a stock solution, prepared as described by previous workers[1,2] and containing 100 mgm. β-indolylacetic acid and 2 ml. 95 per cent ethanol per litre. Glucose was used as carbon source and the inorganic salts were supplied as a Craig and Trelease[3] solution modified by using ferric ethylenediamine tetraacetate as the iron source, by addition of molybdic acid (0·017 mgm./l.), and by adjustment of the *p*H to 5·0. The activity of ethanol was detected when the alga was supplied with sub-optimal levels of glucose (for example, 0·02 per cent) (Table 1). The greater final yield, both in cell numbers (hæmocytometer count) and in algal dry weight (dried at 80° C. for 24 hr.) resulting from addition of ethanolic β-indolylacetic acid was not reproduced by equivalent concentrations of aqueous β-indolylacetic acid and occurred under conditions where the glucose was completely depleted from the medium by the alga (glucose estimated colorimetrically using a modification of Wager's method[4]) (Table 2). Increases of 0·117 (Table 2) and of 0·199 mgm./ml. algal dry

Table 1. The Effect of the Ethanol Content of the β-Indolylacetic Acid Solution on the Growth of *Chlorella vulgaris*, Brannon 1, cultured in the dark on Media containing 0·02 and 1·0 per cent Glucose

Initial population 100 cells/mm.³

Ethanol addition	Cells/mm.³ after 268 hr.	
	With 0·02 per cent glucose	With 1·0 per cent glucose
No addition	9,600	38,440
0·2 ml./l.	12,950	36,620
0·6 ml./l.	24,770	38,380

Table 2. The Effect of 20 mgm./l. β-Indolylacetic Acid added as an Ethanolic and as an Aqueous Stock Solution on the Growth in 240 hr. of *Chlorella vulgaris*, Brannon 1, cultured in the Dark in Medium containing 0·02 per cent glucose

Initial population 100 cells/mm.³

Addition	Cells/mm.³	Algal dry weight (mgm./ml.)	Glucose utilized (mgm./ml.)
No addition	8,150	0·275	0·2
20 mgm./l. β-indolylacetic acid aqueous	9,230	0·268	0·2
20 mgm./l. β-indolylacetic acid ethanolic (0·4 ml. ethanol/l.)	20,150	0·392	0·2

Table 3. Ethanol as Sole Source of Carbon for the Growth of *Chlorella vulgaris*, Brannon 1, in the Dark

Initial population 100 cells/mm.³

Carbon source	Cells/mm.³ after 240 hr.
1·0 per cent glucose	31,050
1·0 per cent ethanol	1,550
0·5 ,, ,,	1,450
0·1 ,, ,,	24,450
0·05 ,, ,,	19,000
0·01 ,, ,,	13,250

weight resulted in separate experiments from the addition of 20 mgm./l. β-indolylacetic acid as a solution containing about 0·316 mgm. ethanol/ml. ≡ 0·165 mgm. ethanol-carbon/ml.).

This enhancement of growth by ethanol was only observed when the culture medium contained limiting concentrations of glucose; with 0·02 per cent glucose the growth-curves (cells/mm.³) in presence and in absence of ethanol were superimposed for the first 90 hr. of culture, but beyond this time the cultures receiving ethanol continued active growth while the control cultures entered the stationary phase. The optimum concentration of ethanol when used as sole carbon source was at or below 0·1 per cent (about 0·02 *M*) (Table 3); at 0·5 per cent, ethanol inhibited cell division as compared with the carbon-omitted control.

Ethanol is actively respired by this strain of *Chlorella*, giving a rate of uptake of oxygen in the Warburg flask of 24·7 μl./10^7 cells/hr. (averaged over 22 hr.) with 0·05 *M* ethanol as compared with 43·8 μl./10^7 cells/hr. with the optimum glucose concentration (0·028 *M*). With an initial population of 4×10^3 cells/mm.³ and 2·5 ml. suspending medium, the respiratory quotient with 0·02 per cent glucose remained at or slightly above 1·0 during a 24 hr. test although, due to sugar depletion, the rate of uptake of oxygen fell to a very low level by 18 hr. Addition at 12 hr. of ethanol to give a concentration of 0·08 per cent depressed the respiratory quotient during the period 12–24 hr. to give an average value of 0·35, and during the period 18–24 hr. the respiratory quotient was almost zero, oxygen uptake proceeding with almost no evolution of carbon dioxide.

Methanol is the only other alcohol, from a number that have been tested in our laboratory, which promotes growth and respiration when supplied as sole carbon source to our strain of *Chlorella*. It is of very low activity and promotion of growth and respiration only occurs over a narrow concentration range. Increase in number of cells over the control from which carbon was omitted was 3–4 per cent (0·025 *M* methanol) of that occurring in 1 per cent glucose, whereas ethanol supports growth-rates up to 75 per cent of those in glucose. In a direct comparison, the stimulation of uptake of oxygen was, with methanol (0·05 *M*) 16 per cent and with ethanol (0·05 *M*) 53 per cent of that in 0·028 *M* glucose.

A marked stimulation of growth from the addition of ethanol has also been observed with cultures of *Chlorella vulgaris*, Pratt, growing at 26° C. in inorganic medium and receiving at their under surface 350 lux from daylight fluorescent tubes. The culture vessels were 100 ml. wide-mouthed conical flasks. These contained 50 ml. medium, inoculated with 100 cells/mm.³. 'Aerated' cultures received, in a fine stream of bubbles, about 20 ml./min. of a mixture of 95 per cent air and 5 per cent carbon dioxide for 1 hr. every 24 hr.; 'non-aerated' cultures were gently agitated once a day to disperse the cells. Under both experimental conditions ethanol stimulated growth (Table 4). The cell densities obtained in the 'aerated' cultures were much higher than could be achieved under the most favourable conditions of 'dark' culture adopted. The very great increase in cell number resulting in these 'aerated' cultures from the addition of 'ethanol' has not yet been examined in terms of carbon increase. Marked stimulation of growth could also be obtained by supplying glucose to these illuminated cultures.

Table 4. The Effect of Ethanol on the Growth of *Chlorella vulgaris*, Pratt, cultured in Fluorescent Light (350 Lux)

Initial population 100 cells/mm.³

Addition	'Non-aerated' cultures after 240 hr.	'Aerated' cultures after 192 hr.	
	Cells/mm.³	Cells/mm.³	Algal dry weight mgm./ml.
No addition	4,000	41,000	0·86
0·01 per cent ethanol	5,500	46,500	0·90
0·05 ,, ,,	9,400	58,000	1·14
0·10 ,, ,,	16,500	72,000	1·3
0·20 ,, ,,	11,500	114,500	1·76
0·30 ,, ,,	6,500	—	—
0·35 ,, ,,	—	139,200	2·21
0·40 ,, ,,	4,600	—	—
0·50 ,, ,,	2,400	101,500	2·55

Brannon[1] concluded that the ethanol introduced into his media was probably removed during autoclaving for 30 min. at 15 lb./in.². We have not reproduced Brannon's media but have found that our medium, containing initially 0·5 per cent ethanol, still gives a reaction for alcohol (assessed colorimetrically following oxidation to acetaldehyde with potassium bichromate–sulphuric acid) after autoclaving for 60 min. and that such media support, as a result of the ethanol addition, a significantly enhanced growth in illuminated 'non-aerated' cultures. These results not only raise the question of how far the presence of ethanol has been responsible for earlier reports of the stimulation of the growth of *Chlorella* by auxins but also suggest that the metabolism of ethanol in this organism should be the subject of further study.

A more detailed account of some of the results referred to here will be published elsewhere.

H. E. Street
D. J. Griffiths
C. L. Thresher
M. Owens

Department of Botany,
University College,
Swansea.
October 7.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Effect of Heat Treatment on the Sintering of 'Active' Ceramic Oxide Powders

In recent years much attention has been paid to the preparation of 'active' oxide powders by decomposition of compounds; the oxide powders obtained in this way are agglomerates of fine crystallites, have high surface area and show enhanced sintering characteristics compared with the highly calcined powders normally used[1]. With pure powders prepared in this way, variations have been noted in the sintering behaviour which are difficult to account for.

It has now been found that in the sintering of compacts of these oxide powders, intermediate heat treatment at a temperature lower than the normal sintering temperature significantly increases the final bulk density. Two conditions are necessary to benefit from the effect: (1) The calcination of the original compound, such as the hydroxide before pressing, should be carried out at an optimum temperature, for example, with beryllium between 1,000° and 1,250° C. Compacts made from powder calcined at lower temperatures crack excessively on sintering, whereas the particle-size of powder calcined at higher temperatures is too large for appreciable densification to occur. (2) The pressed compact should be annealed at or near the calcination temperature of the powder and at successively higher temperatures to the temperature at which the rate of densification is high enough for the maximum bulk density to be reached in a reasonable time. In the annealing treatment, weld junctions are formed between the particles in contact in the pressed powder and the fine pore structure of the pressed compact is retained until the temperature is reached at which the rate of sintering becomes rapid. If the annealing treatment is omitted and the compact rapidly raised to the maximum temperature, uncontrolled shrinkage occurs within the agglomerate particles and these separate within the compact to form fissures and pores too large to be eliminated afterwards. The final bulk density is therefore much lower.

As an example, compacts made from beryllium oxide (BeO) prepared by calcining the hydroxide to 1,250° C. sinter to bulk densities of 2·2 gm./c.c. (that is, 27 per cent porosity) if rapidly heated to 1,600° C. in 1 hr. If similar compacts are heat-treated for several hours at 1,300–1,400° C. prior to the temperature being raised to 1,600° C., bulk densities of 2·75 gm./c.c. (that is, 8 per cent porosity) are obtained.

Confirmation of the hypothesis put forward to explain this effect has been obtained by applying an external pressure at high temperatures to the compact. Here the particles are prevented from separating at the points of contact by the external pressure, and high bulk densities result in all cases, independently of the heat treatment.

A fuller account of this work will be published elsewhere.

D. T. Livey
P. Murray

Metallurgy Division,
United Kingdom Atomic Energy Authority
Research Group,
Harwell.

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Investigation of the Ionosphere using Signals from Earth Satellites

I propose to discuss some possible effects of the ionosphere on the radio signals from artificial satellites on the basis of my theoretical results[1].

The occurrence of focusing of radio waves from the point antipodal to the observer could probably be demonstrated from measurements of Doppler frequency shift (Fig. 1*a* (i)). Let O denote the position of the observer, S the satellite, Z and N the points on the orbit of the satellite in the observer's zenith and nadir. Let the critical frequency f_c of the ionosphere increase from Z to N, where it attains a value slightly greater than the transmission frequency, f_0, of the satellite. Neglecting the presence of the Earth, the trajectories of ray paths and the corresponding Doppler curve are shown in Fig. 1*a* (i) and (ii), using dotted and continuous lines for the free-space and ionospherically propagated cases respectively. When the satellite moves from a typical point K to N, the frequency received via the free-space path increases slowly to the value f_0 transmitted by the satellite. In the ionospheric case, however, the frequency will remain nearly constant at a value f_K

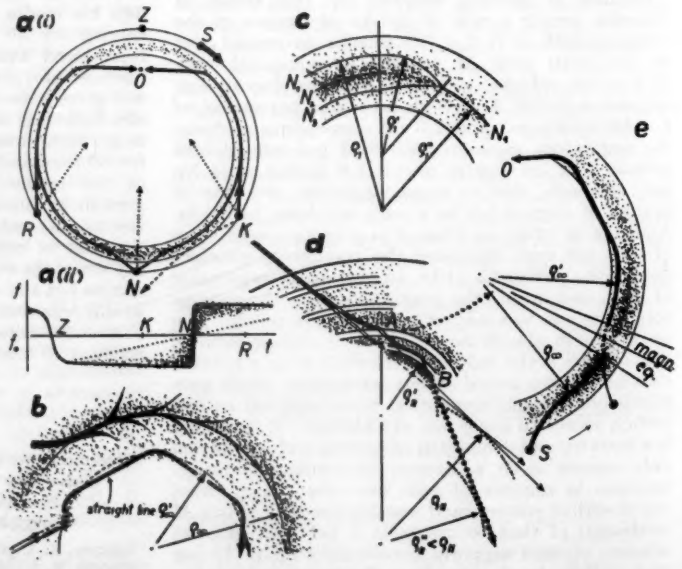

Fig. 1

until N is reached, after which the received frequency will rise suddenly to a value f_R, given by : $f_R - f_0 = f_0 - f_K$. In the vicinity of N, transmission of the signal over all possible great circle paths towards the antipodal point Z will occur. In this case all frequencies between f_K and f_R will be received. If reception occurred only within a narrower frequency band, this would indicate that propagation was effective only in a certain preferred range of directions. The maximum probability of multi-path propagation between S and O occurs when the satellite passes N.

Various theoretical modes of long-distance propagation around the Earth will now be discussed. It can be shown[2] that perpetual propagation of radio waves around the Earth in a conventional spherically symmetrical ionosphere is possible if :

$$\frac{d\mu}{d\rho} = -\frac{\mu}{\rho}$$

where μ denotes radio refractive index and ρ the radial distance. Provided the ionospheric critical frequency is smaller than the satellite frequency f_0, there usually exist two levels in the ionosphere which fulfil this condition. One of these critical levels, lying close below the maximum of electron density (denoted in Fig. 1*b* by ρ_∞), does not support stable propagation, since the smallest inhomogeneity of electron density will produce a considerable divergence of rays in all directions. The lower critical level (denoted by ρ'_∞) can support more stable propagation since small inhomogeneities will only cause the wave to oscillate along this critical level. On the other hand, to realize this desired propagation from S to O, there must always exist two suitable inhomogeneities, one to bring the ray from higher levels to this critical level and the second to take it down to the ground-level. The most probable mode of long-distance propagation seems to occur when a slight increase of electron density occurs along the ray path. Then a ray just passing the upper layer, but going so nearly tangentially that it cannot attain the surface of the Earth, can be trapped between the two levels. Let a further variation of altitude, electron density or thickness of the layer change the height of both reflecting levels (see the $\mu\rho$-diagram of ref. 2) ; when the lower one in effect falls to the surface of the Earth, the signal can be received.

Another mode of long-distance propagation by means of the ionosphere is possible, theoretically. Consider a layer the electron density of which decreases slightly in the horizontal (Fig. 1*a* (i) and *c*). Then an almost tangential ray, which in a layer with perfect spherical symmetry would usually be reflected, could pass farther into the ionosphere ; for a suitable decrease of f_c, long-distance propagation could then be realized. The penetration of the ray deeper into the ionosphere is best shown by reference to Fig. 1*d*. Suppose that the ionosphere is composed of a number of regions of finite thickness and uniform electron density separated by infinitesimally thin regions of zero electron density. According to ref. 1, so long as the layer traversed has perfect spherical symmetry and no horizontal variation, the ray is in the un-ionized regions tangential to the sphere designated by $\rho_\parallel$, concentric with the Earth's surface. At the point A, where the contour of constant electron density ceases to be spherical and decreases in radius of curvature, the ray must be tangential to a sphere of smaller radius $\rho'_\parallel$ in the intermediate un-ionized regions. Thus a ray approaching the ionosphere almost tangentially will not be reflected, but will pass through the layer very obliquely, covering a large horizontal distance.

Also the reported discrepancy[3] between the times of closest approach deduced from Doppler and direction-finding measurements might have other causes than an inclination to the horizontal of the lower boundary of the layer. It could be explained by an increase or decrease of the maximum electron density in some horizontal direction. The displacement of the centre of curvature of the contours of constant electron density from the plane of propagation could result in a considerable azimuthal deviation of the ray.

In long-distance propagation of satellite signals, an important part seems to be played by the deep local minimum of electron density usually present at the magnetic equator (Fig. 1*e*). The ray running along the ionosphere is bent slightly towards the Earth and after passing this electron density minimum is bent back to the horizontal direction. In this way it could easily attain even the stable 'critical level'. (Direct reflexions between Earth and ionosphere are not, in the early morning hours, very probable on 40 Mc./s. as the decrease of critical frequency towards the polar regions is usually very rapid, and the wave would pass through the ionosphere into space.)

Theoretically, all these modes of propagation from the antipodal point are thought to be possible on 40 Mc./s., although in practice none of them will appear frequently. A satisfactory answer to the question of what mode of propagation is preferred could probably be given by a detailed study of the Doppler curves, of direction-finding measurements and the variation of band-width of the received signal when the satellite is deep below the optical horizon.

E. Woyk
(E. Chvojková)

Astronomical Institute,
Czechoslovak Academy of Sciences,
Praha 12.

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Horizontal Drift Measurements in the Ionosphere near the Equator

Measurements of horizontal drift in the ionospheric *E*- and *F*-layers have been made regularly at Ibadan (magnetic latitude 2½° S.) since June 1957. These measurements are of importance in view of the theory of the origin of such drifts put forward by Martyn[1]. According to this theory, a phase reversal of the east–west component of drifts in the *F*-region should occur at latitudes 35° N. and 35° S. Confirmation of this phase reversal has been obtained by Purslow[2] and Rao and Rao[3] at Singapore and Waltair (India) respectively. Martyn's theory further predicts that at the magnetic equator the westward drift in the *F*-layer during the daytime should be of the order 200 m./sec., about twice that obtained in temperate latitudes.

The method used to measure horizontal drifts at Ibadan is similar in principle to that originated by Mitra[4], using a pulse transmitter and three spaced receiving aerials. The aerials are half-wave dipoles at 2·4 Mc./s. and are spaced at the corners of a right-angled triangle with its hypotenuse in the magnetic north–south plane, and with sides of length 127 m., 127 m. and 180 m. A film speed of about 20 cm./min.

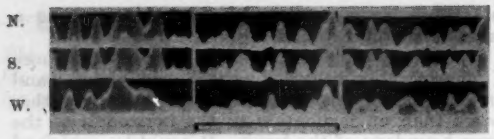

Fig. 1. Sample drift record

is normally used, and a typical film record obtained is shown in Fig. 1. *E*-layer drifts are measured using a frequency of 2·4 Mc./s. and *F*-layer drifts with a frequency of 5·7 Mc./s.

The normal method of analysis of drift records consists in measuring time-shifts between pairs of records. A simple calculation then yields the drift velocity. It is assumed in this method that the amplitude pattern on the ground remains constant in detail as it moves and that it is statistically isometric so that its statistical properties show circular symmetry. If the second assumption is not true, considerable error will arise in the apparent direction of the drift.

It is seen in Fig. 1 that at Ibadan the amplitude-fading records for the north and south aerials are almost identical and that there is no measurable time-shift between them. The record from the west aerial is similar in form but displaced in time relative to those from the north and south aerials. This strongly suggests that the amplitude pattern on the ground is elongated in the north–south direction, and an analysis of the type developed by Phillips and Spencer[5] has been made on representative records. Phillips and Spencer showed that an amplitude pattern in which the irregularities are on the average anisometric can be represented to a first approximation by a 'characteristic ellipse' representing a contour of equal auto-correlation. The axial ratio and angle of orientation of this ellipse can be obtained by a laborious process involving the calculation of the cross-correlation functions between the different pairs of aerials. This calculation is best done by means of an electronic computer, and we are indebted to the Cavendish Laboratory, Cambridge, for the analysis of certain records using the EDSAC. Other records have been separately analysed by one of us (J. H.) and the results of both analyses are summarized in Table 1.

Table 1

Layer	Mean axial ratio	Mean angle of orientation of major axis in deg. E. of magnetic N.	No. of records analysed
E	5	0°	24
F	11	0°	24

The orientations of the major axes of the ellipses are almost without exception within a few degrees of magnetic north–south and the mean orientation for both *E*- and *F*-layers is less than one degree from the magnetic meridian. There is evidence that the anisometry is more pronounced in the *F*-layer than in the *E*-layer, the mean axial ratios of the characteristic ellipses being 11 and 5 respectively. However, the values are widely distributed and, with the limited number of values at present available, no great significance should be attached to the actual values 11 and 5.

Comparable results are rather scarce and somewhat contradictory. Spencer[4], at Cambridge, using a radio stellar technique, has reported the presence of irregularities in the *F*-layer elongated by a factor of at least 5 : 1 along the Earth's magnetic lines of force. Phillips and Spencer[5], however, found that the axial ratios were usually less than 1·5 in the *E*- and *F*-layers for the cases that they examined using the pulse reflexion method. They also found that there was no preferred direction for the axes of the ellipses. Purslow states in a private communication that, at Singapore, axial ratios of about 2 : 1 are obtained. It is difficult to reconcile this large difference between the results at Singapore and Ibadan, which are stations of similar latitude.

The effect of the north–south elongation of the amplitude pattern is to mask the meridional components of drift. The true direction of drift can be obtained from the full correlation analysis, but this is a laborious process even with the aid of a computing machine. The east–west component, however, can be obtained from a consideration of time shifts between the fading records at the north–south and west aerials. Results have been analysed in this way for about 25 complete days in August and September 1957. Figs. 2*a* and 2*b* show the mean diurnal variation of the east–west component of the drift velocities in the *E*- and *F*-layers respectively. It is seen that in both layers the drift is towards the west during the daytime and towards the east at night, in agreement with the predictions of Martyn's theory, and in opposite phase to that found in temperate latitudes. Harmonic analysis of the *F*-layer data brings out the predominant 24-hr. period component. It is found that the east–west velocity, $V_{E\text{-}W}$, can be represented by the function :

$$V_{E\text{-}W} = -10{\cdot}5 + 111\sin(t + 68°) + 26\sin(2t + 54°)$$
(m./sec.).

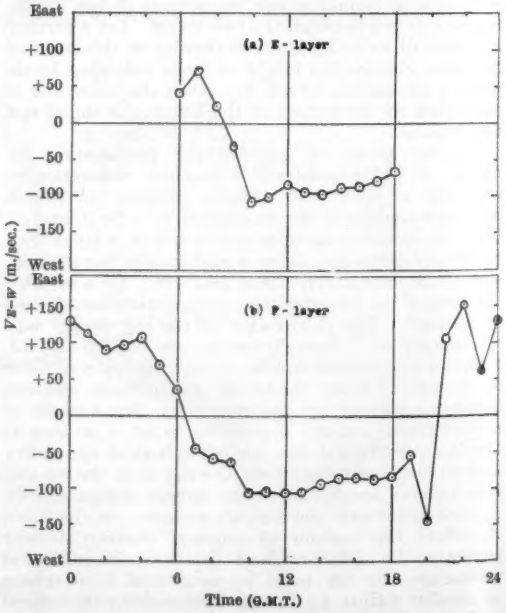

Fig. 2. Diurnal variation of east–west drift component (*a*) in the *E*-layer and (*b*) in the *F*-layer

This may be compared with Purslow's results[2] for Singapore, and Rao and Rao[3] for Waltair:

$V_{E\text{-}W} = 1{\cdot}7 + 88\sin(t + 59°) + 3\sin(2t + 210)$ (m./sec.) Waltair (autumn).

$V_{E\text{-}W} = 18 + 45\sin(t + 84°) + 22\sin(2t + 38°)$ (m./sec.) Singapore.

It is seen that the phases of the 24-hr. components are similar at the three stations although there is considerable variation in the amplitudes.

The westward daytime drift velocity in the *F*-layer of about 105 m./sec. at Ibadan is smaller than that predicted by Martyn (200 m./sec.), but it should be remembered that Ibadan is not placed directly beneath the centre of the equatorial 'electrojet' current. The velocity at Ibadan is larger than those at Singapore and Waltair, which are themselves farther from the magnetic equator. It is quite possible that larger velocities would be obtained at stations a few hundred kilometres north of Ibadan.

N. J. Skinner
J. Hope

University College,
Ibadan, Nigeria.

R. W. Wright

University College of Ghana.
Sept. 16.

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A Man-made or Artifical Aurora

At 1051 G.M.T. on August 1, 1958, Mr. J. G. Keys, observer-in-charge at Apia Observatory, latitude 13° 48′ S., longitude 171° 46′ W., witnessed at Apia a manifestation which was at first thought to be a display of the aurora australis but is now believed to be due to a nuclear bomb explosion in the upper atmosphere. The occurrence of an auroral display in the tropics is always of unusual interest to geophysicists because of its exceeding rarity. In particular, the Aurora Australis has been reported at Apia on one occasion only, and then only in association with the severe magnetic storm of May 13–16, 1921. This display was described in detail by Angenheister[1] and Angenheister and Westland[2].

The display seen by Keys is of more than usual interest because of the extraordinary effects associated with it. Briefly, his description of the manifestation is as follows.

The display was first observed on August 1 at 1051 G.M.T. with bright rays in the western sky extending from bearing 235° and bearing 286° where the altitude of the rays was 12°. On the bearing of 235° the rays disappeared behind coconut trees at an altitude of 10·5°. It is inferred that the rays extended towards the southerly horizon. This manifestation persisted for about 6 min., then gradually diminished to a red glow centred on a bearing of 247°. This glow faded completely at 1105 G.M.T. The rays were at first violet, covered with reds and gradually changed to greens. There was a crimson arc with centre elevation 32° on a bearing of 340° and this gradually faded. Three or four red bands were seen with their centres approximately due south at an elevation of about 30–40°, and these faded rapidly. The night sky was clear with one-eighth cumulus cloud at 2,500 ft., and the moon was just past full. Associated with these manifestations were radio fade-outs which lasted from one to several hours.

Keys noticed a most unusual pronounced sudden commencement on the Apia normal and rapid run magnetograms covering the time of the above described manifestation, and sent copies to me. At 1050 G.M.T. the Apia magnetograms showed pronounced sudden commencement with reverse impulse *ssc**, and for the 3-hr. period 0900–1200 G.M.T. the *K*-index was 6. The Amberley (latitude 43° 09′ S., longitude 172° 43′ E.) magnetograms show no extraordinary effects and in particular no sudden commencement with or without reverse impulse.

The sudden commencement recorded at Apia is itself most unusual because of its form, which was similar to that which one would expect at a high-latitude station near the auroral zone, and not its usual simple form. The occurrence of sudden commencements with reverse impulse *ssc** is comparatively rare at Apia, and when they do occur the reverse impulse has a very small amplitude. In this case, the reverse amplitude was comparatively large and well defined. The sudden commencement in the *D* trace at Apia is usually very small, seldom exceeding a minute or two. In this case the amplitude of the sudden commencement in *D* was 9 min. The magnetic disturbance lasted about an hour and seems to have been superposed on a minor bay disturbance which was already in progress before the sudden commencement.

Auroræ, when seen in tropical regions, have always been associated with severe world-wide magnetic storms. The Amberley magnetograms show that at the time in question there was no severe magnetic storm in progress except a bay type of disturbance with *K*-index 3. A comparison of the Amberley and Apia magnetograms shows definitely that the magnetic disturbance recorded at Apia was not world-wide but appeared to be localized in the Central Pacific area.

If an aurora australis had been seen at Apia it should have been seen low down in the southern sky. In the manifestation described above, rays were seen in the western sky and a crimson arc was seen at an altitude of 32° in the northern sky. It was unlikely that the manifestation was the aurora borealis because Apia lies well to the south of the equator and no world-wide severe magnetic storm was in progress.

The abnormal directions in which the manifestations were seen, as well as the abnormal magnetic effects recorded at Apia, point to the fact that it was not a normal auroral display.

Approximately at the time of the sudden commencement recorded at Apia, American scientists exploded a nuclear bomb high in the upper atmosphere, at a height of 100 miles according to newspaper reports—over Johnston Island. There seems to be little doubt that the unusual magnetic effects recorded at Apia are related to this explosion and that the manifestation seen at Apia was a man-made or artificial aurora due to a nuclear explosion in the upper atmosphere.

A study of the effects due to this explosion may throw considerable light on the theory of magnetic storms and auroræ. It would be of great interest to know whether other magnetic stations in the

Central Pacific recorded similar abnormal magnetic effects.

A. L. Cullington
Magnetic Survey,
Geophysics Division,
Department of Scientific and Industrial Research,
Botanic Gardens,
Christchurch, New Zealand.
Aug. 25.

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Emission Spectrum of N_2O^+

In the course of a study of the luminescence of gases irradiated by X-rays (to be published), some unknown bands were observed from nitrous oxide. All the other gases studied emit well-known band systems, usually of the parent gas or its ion. Gases at pressures between 1 and 700 mm. were irradiated with soft X-rays (45 kV. peak) from a beryllium-window tube, and the spectra photographed or scanned with a photomultiplier through a Hilger *D.96 f* 2 quartz spectrograph. The emission from nitrous oxide consisted of the unknown bands at about 3680, 3540 and 3380 A. and the nitric oxide β system (the bands in the $v' = 0$ progression between $v'' = 3$ and 13 were observed). The latter system has been observed previously as fluorescence from nitrous oxide irradiated with vacuum ultra-violet light[1]. The two sets of bands differ in their dependence on pressure; the β bands suffer little collisional deactivation at high pressures whereas the new bands are strongly 'quenched', but they must be much more strongly excited since the intensities are roughly comparable at 600 mm. Since carbon dioxide excited by X-rays emits CO_2^+ bands ($^2\Sigma_u - {}^2\Pi_g$, ref. 2, and $^2\Pi_u - {}^2\Pi_g$, ref. 3) and these show a similar pressure dependence, the new bands are tentatively ascribed to N_2O^+. Emission by nitrous oxide (N_2O) itself is unlikely from a consideration of its excited states[4].

The observed light intensity was very small (8-hr. exposures with ½ mm. slit-width were necessary to photograph the spectra on *HPS* plates) and the dispersion low (100 A./mm. at 3500 A.) so the bands could not be properly characterized with this apparatus. Therefore an attempt to excite the bands in a discharge tube was made. If the identification is correct, they should appear in the negative glow; low current density and rapid flow of the gas would be necessary to reduce the decomposition of nitrous oxide which occurs in the discharge.

The discharge tube was a T-shaped 'Pyrex' tube, with ¾ in. internal diameter, 2 in. long aluminium tube as cathode and a smaller aluminium tube in a side-arm as anode; nitrous oxide was pumped through the tube from cathode to anode; spectra were photographed through a silica window with a Hilger medium quartz spectrograph. The positive column in the side tube was coloured green or pink (first positive bands of molecular nitrogen); the cathode glow was blue. The new bands appeared in the cathode glow and behaved as expected. A detailed study of the excitation conditions was not made, but the best conditions seemed to be 1 mm. mercury pressure and minimum discharge current (8 m.amp.). The bands also appeared at higher pressures (3–4 mm.); though more current was needed (50 m.amp.), the flow rate was probably higher. The nitrogen second positive and first negative systems and the nitric oxide β and γ systems were also present; the nitrogen bands were of comparable intensity with the new bands and may have obscured some of them. A better separation from these emissions from decomposition products of nitrous oxide would probably be obtained at higher rates of flow.

Table 1. Wave-lengths and Intensities of the New Band System

(A.)	I	(A.)	I	(A.)	I
3380	*S*	3595	*MS*	3773	*WM*
3396	*S*	3611	*M*	3823	*M*
3429	*VS*	3626	*W*	3843	*S*
3434	*W*	3636	*WM*	3864	*S*
3454	*MS*	3653	*MS*	3874	*W*
3470	*MS*	3661	*M*	3928	*W*
3481	*W*	3673	*MS*	3961	*W*
3493	*M*	3687	*VS*	3981	*W*
3516	*MS*	3706	*VS*	4008	*WM*
3521	*M*	3720	*W*	4030	*WM*
3541	*VS*	3746	*MS*	4126	*W*
3558	*VS*	3764	*WM*	4225	*W*

The band heads and estimated intensities are listed in Table 1. A number of very weak bands were also observed and probably belong to this system; the strong bands were clearly degraded to the violet. Though further evidence is required, the most likely emitter of these bands seems to be N_2O^+. Further study of them would be of interest for comparison with the isoelectronic CO_2^+ (refs. 2 and 3) and NCO (ref. 5).

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B. Brocklehurst*
Atomic Energy Research Establishment,
Harwell, Didcot, Berks.
Aug. 21.

* Present address: Department of Chemistry, University of California, Berkeley 4, California.

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Abnormally High Fatigue Strengths in Aluminium Alloy Extruded Bar

In 1932, Matthaes[1] reported that the tension properties of aluminium alloy extrusions in the longitudinal direction were significantly greater than in the transverse direction, and it is now well known that both the ultimate tensile stress and proof stress values may be 20–30 per cent greater than the respective values for rolled or forged material. However, it has been observed[2] that the fatigue properties are little affected by the extrusion process. In view of this the following results are of interest.

Unnotched and notched rotating cantilever fatigue tests at 12,000 cycles/min. have been conducted on two batches of aluminium alloy extruded bar, one of 0·510 in. diameter to specification *S.A.A.*(*E*)*2D*.649 (24*S*-*T*) and the other of 0·750 in. diameter to specification *D.T.D*.683/3 (75*S*-*T*), both batches being of Australian manufacture.

Table 1 shows that the tension properties of both batches are far in excess of the specification properties for these alloys. Fatigue tests using specimens of 0·300 in. nominal test diameter have indicated that the materials exhibit several unusual characteristics.

In Fig. 1 are shown the mean *S*–*N* curves for specimens of the 24*S*-*T* material; these are also typical of

Table 1. TENSION PROPERTIES OF THE EXTRUDED ALLOYS

	0·1 per cent proof stress (lb./sq. in.)	0·2 per cent proof stress (lb./sq. in.)	Ultimate tensile strength (lb./sq. in.)	Elongation (per cent)	Hardness (B.H.N.)
Spec. *S.A.A.*(*E*)2*D*.649 (minimum)	38,000	40,000	63,000	12	—
(as received)	60,000	62,000	86,000	13·5	141
24*S*–*T*4 (typical)	—	49,000	69,000	18	120
Spec. *D.T.D*.683/3 (minimum)	67,250	—	78,500	7	—
(as received)	81,500	83,750	93,000	8	172
D.T.D.683 (typical)	82,500	—	90,000	10·5	170

the *D.T.D*.683. The unnotched curve was obtained using specimens finished by diamond turning, while the notched specimens were machined by plunge cutting with a form tool. Notch radius was 0·080 in., giving a theoretical stress concentration factor of approximately 1·5. For these materials the unnotched fatigue strengths at 10^8 cycles are about 50 and 80 per cent greater respectively than typical values quoted for the two alloys, that is, approximately 30,000 lb./sq. in. compared with 20,000 lb./sq. in. for the 24*S*-*T* and approximately 42,000 lb./sq. in. compared with 23,000 lb./sq. in. in the case of the *D.T.D*.683.

Fig. 1 also shows that the notched fatigue strength at 10^8 cycles (approximately 25,000 lb./sq. in. for each alloy) is likewise higher than might be expected, but more remarkable is the unusual shape of the curve. Notched specimens, particularly those tested

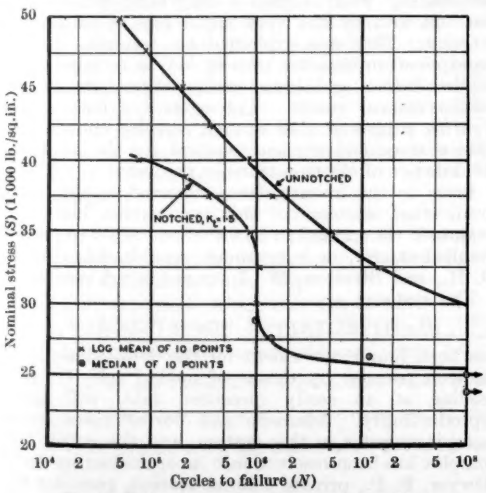

Fig. 1. Fatigue curves for 24*S*-*T* aluminium alloy

Fig. 2. Longitudinal section through fractured 24*S*-*T* notched fatigue specimen, radius 0·080 in.

at high nominal stresses, tended to give a 'conical' type of fracture, a good example of which is shown in Fig. 2. This type of fracture is similar to that reported by Vitovec[3] after applying a high static preload to a notched fatigue specimen.

Metallographic examination of the alloys has indicated a marked directionality effect along the length of the bars, but at this stage no other unusual characteristics have been observed.

A possible explanation is that the abnormal characteristics in these materials may be associated with some peculiar extrusion texture, and that this has caused significant modifications in the mode of precipitation in the alloys. In view of the practical implications of the high properties observed, it is intended to make a more detailed investigation of these materials.

This work forms part of a programme on the fatigue of aircraft materials being conducted at the Aeronautical Research Laboratories in Melbourne. Acknowledgment is made to the Chief Scientist, Australian Defence Scientific Service, Department of Supply, Melbourne, Australia, for permission to publish this communication.

J. M. FINNEY
J. Y. MANN

Aeronautical Research Laboratories,
Australian Defence Scientific Service,
Department of Supply,
Melbourne.

Aug. 19.

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A Phosphatic Band underlying Bauxite Deposits in Jamaica

IN 1957, during a detailed examination of the bauxite deposits in Jamaica, suggested by Dr. D. A. Bryn Davies, managing director of Alumina Jamaica, Ltd., and sponsored by that Company, I noticed the occurrence of a hitherto unrecorded sedimentary band separating red bauxite from underlying white Tertiary limestones. The band is extremely local in occurrence. So far as at present known, it is only typically developed within a limited area around the Kirkvine Works of Alumina Jamaica, near Mandeville, and at Grove Place, about 4 miles to the north-west. It is known to be absent in many other areas. It has, however, certain interesting characteristics which may have some bearing on the history and age of the bauxite deposits. For this reason, and because it may lead to the recording of other occurrences in Jamaica, or even in association with the similar bauxite deposits in Haiti and the Dominican Republic, it seems worth

placing on record the following summary account. It is intended to include a more detailed description in a later general account of the bauxite deposits.

In nearly all the occurrences examined, the band was found to be very thin and inconspicuous. It seldom exceeds one foot in thickness, and it is often only one inch or less thick. It tends to be lenticular in habit, and is discontinuous within the limited area in which it has so far been recognized. In spite of its thinness, it may include several layers or laminæ differing in composition, or in appearance.

As a whole, the band has the following distinctive chemical characteristics:

(1) It is often highly phosphatic, some layers consisting almost entirely of white collophane.

(2) Spectrographic examinations carried out by Aluminium Laboratories, Ltd., at Arvida, Quebec; by Mr. C. O. Harvey, in the Chemical Laboratories of the Geological Survey, London; and, at the suggestion of Dr. A. Muir, in the laboratories of the Soil Survey Division, Rothamsted Experimental Station, Harpenden, England, disclosed the presence of a considerable number of rare or uncommon elements, including silver, barium, beryllium, cadmium, cobalt, chromium, copper, nickel, lead, strontium, tin, yttrium, zinc and zirconium. While most of these are present only in minor or very minor amounts, some, notably zinc, cadmium, beryllium and yttrium, were found to be present in surprisingly high concentrations in certain samples.

(3) The band is radioactive to an extent appreciably greater than the overlying bauxite. Determinations made in the laboratories of the Atomic Energy Division of the Geological Survey, London, on ten different samples of sediment gave results indicating a content of radioactive matter ranging from 0·006 to 0·028 (average 0·0145) per cent U_3O_8 equivalent, that is, quantitatively, the radiation detected is equivalent to that which would be emitted if the stated amount of U_3O_8 were present in the rock, to the exclusion of other radioactive elements. No attempt has been made as yet to determine what element or elements cause the radiation. Mr. S. H. U. Bowie, chief geologist of the Division, informs me that the figures obtained by his staff during a survey of radioactivity in Jamaica indicate the radioactivity of the bauxite to be about one-twentieth of that of the most active of the phosphatic sediments.

A further characteristic of the phosphatic band is that it is fossiliferous, the organic remains consisting almost entirely of very small (< 10 mm.) fish teeth. A large collection of these teeth was submitted to Dr. E. I. White, keeper of palæontology in the British Museum (Natural History), who states that the assemblage is definitely marine, and includes teeth of small carcharinid sharks, chaetodonts, sparids, labrids (wrasse) and scarids; but it is not possible on the basis of the material submitted to assign a more definite age than Tertiary (or later) to the assemblage.

It may be added that a few specimens of teeth were tested for radioactivity, and gave a result indicating 0·008 per cent U_3O_8 equivalent.

The above characteristics of the sedimentary band, taken as a whole, suggest that it should be classified as a marine phosphorite, comparable in general character with, for example, the marine phosphorites of the Bone Valley formation in Florida. If this comparison can be sustained, the Jamaican deposits probably represent the attenuated and re-sorted remnants of a once more extensive phosphorite deposit, younger than the karstified white limestones (Upper Eocene to Lower Miocene) on which it rests. Deposition may have taken place during the submergence of Jamaica in Plio-Pleistocene time. I have seen evidence of submergence at heights at least 1,500 ft. above present sea-level, and Butterlin[1] records marine terraces in Haiti up to a height exceeding 2,000 ft. (630 metres).

A further point of interest is that the known occurrences of the phosphatic sedimentary band lie on the margin of an area within which there are several deposits of bauxite with an abnormally high phosphate content. The evidence so far available, however, is insufficient to determine whether or not there is any interdependence between the occurrences of phosphatic sediment and the distribution of high-phosphate bauxite.

V. A. Eyles

The Vicarage,
Milton-under-Wychwood,
Oxford.

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Electron Transfer and Thermal Racemization of Ethylenediaminetetraacetatocobaltate(III)

In general, electron-transfer reactions which involve no net chemical change have been studied by the use of isotopic tracers. In 1950, Dwyer and Gyarfas[1] reported that the mixing of *d*-tris(2,2′-bipyridine)-osmium(II) with *l*-tris(2,2′-bipyridine)osmium(III) was followed by the very rapid loss of all optical activity. This was explained by assuming that a rapid electron transfer process led to redistribution of the dextro and lævo configurations among the two oxidation states. Consequently, Dwyer and Gyarfas suggested that optical activity should provide a second convenient method for the study of the kinetics of electron-transfer processes.

Prior to the investigations reported in this communication, systems of this type which had been examined were found to be either too rapid to permit detailed study[2], or very poorly reproducible (Busch, D. H., and Stratton, W. J., unpublished results).

The system:

$$[\text{Co-III (EDTA)}]^- - [\text{Co-II (EDTA)}]^{2-}$$

has been found convenient for the detailed study of electron transfer by means of optical activity, proceeding at an easily measured rate, with good reproducibility. Adamson and Vorres[3] investigated isotopic transfer in this system, and the cobalt(III) complex has been resolved into its optical antipodes[4,5] (Dwyer, F. P., private communication, provides the best method of resolution). Since the cobalt(II) complex is configurationally unstable, electron transfer should be accompanied by racemization, as indicated in the following equation:

$$d\text{-}[\text{Co-III (EDTA)}]^- + [\text{Co-II (EDTA)}]^{2-} \rightleftharpoons [\text{Co-II (EDTA)}]^{2-} + l\text{-}[\text{Co-III (EDTA)}]^-$$

Although *d*-[Co-III (EDTA)]$^-$ is optically stable at room temperature, it does racemize[5] at 100° C. Consequently, a second path for racemization might be observed in accordance with the equation:

$$d\text{-}[\text{(Co-III (EDTA)}]^- \rightleftharpoons l\text{-}[\text{Co-III (EDTA)}]^-$$

Reproducible results have been obtained indicating that the hexadentate complex *d*-[Co-III (EDTA)]$^-$

undergoes racemization at 100° C., and that this racemization process is catalysed by the cobalt(II) complex. The concentrations of the cobalt(III) complex and of the cobalt(II) complex have been varied, as has the ionic strength. The *p*H was maintained in the region $2{\cdot}0 \pm 0{\cdot}2$. The expected pseudo-first-order kinetics in rotation were observed in accordance with the expression:

$$-\ln(\alpha/\alpha_0) = Rt$$

where α is the rotation at any time t, α_0 is the rotation at zero time, and R is the pseudo-first-order rate constant.

The integrated rate law accounting for these two paths is:

$$-\ln(\alpha/\alpha_0) = 2(kb + k')t$$

where k is the second-order constant associated with electron-transfer process, k' is the rate constant for thermal racemization, and b is the concentration of [Co-II (EDTA)]$^{2-}$. Equating coefficients of t in the experimental and theoretical rate equations gives the equation:

$$R = 2kb + 2k'$$

From the linear dependence of R on b, k and k' are evaluated to be $1{\cdot}4\ M^{-1}\text{hr.}^{-1}$ and $0{\cdot}015\ \text{hr.}^{-1}$, respectively. Direct determination of k' also gives an average value of $0{\cdot}015\ \text{hr.}^{-1}$ for five experiments involving zero concentration of cobalt(II) complex.

The results reported by Adamson and Vorres[2] were determined at 60°, 70° and 85° C. Extrapolation of them to 100° C. gives $2{\cdot}1\ M^{-1}\text{hr.}^{-1}$ as the value for the second-order rate constant. It can be shown that k, as defined here, corresponds to one-half the value derived from the McKay equation for electron transfer (isotopic method). Consequently, the value determined here ($1{\cdot}4\ M^{-1}\text{hr.}^{-1}$) should be compared with one-half the value reported by Adamson and Vorres, namely, $1{\cdot}1\ M^{-1}\text{hr.}^{-1}$. These studies will be reported in greater detail at a later date.

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YONG AE IM
DARYLE H. BUSCH
Department of Chemistry, Ohio State University,
Columbus, Ohio. Sept. 3.

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Electronic Configuration d^4 in a Complex Ion

BECAUSE of the instability of the valence states which transition metal atoms must possess in order to have four non-bonding electrons remaining after forming a d^2sp^3 octahedral complex ion, few simple ions of this configuration have been studied. This lack of experimental data has seriously hindered the elucidation of the properties to be expected for a complex ion of this type[1].

In this laboratory we have recently measured the magnetic susceptibilities of the potassium hexa-halo-osmates-IV, K_2OsF_6, K_2OsCl_6 and K_2OsBr_6, and recorded their ultra-violet and visible spectra (200–750 mμ) and their infra-red spectra (2–33μ). Johannesan and Lindberg[2] previously reported that $(NH_4)_2OsBr_6$ exhibited a paramagnetism independent of temperature which they explained on the basis of Kotani's[3] theory of spin-orbit coupling. Nyholm *et al.*[4] have recently shown that the same ideas can be applied to K_2OsCl_6. In both the above cases, a reasonably good agreement with theory is obtained for the magnetic properties of these compounds, if one invokes a rather large amount of spin-orbit coupling, $A = 6{,}400\ \text{cm.}^{-1}$.

We have found that this large amount of spin-orbit coupling will also explain the observed visible spectra for K_2OsCl_6 and K_2OsBr_6 when the predictions of Kotani's theory are combined with certain results from ligand field theory.

In Kotani's theory the spatial degeneracy of the three t_{2g} orbitals is removed, and the resulting levels have energies $-A/2$, $-A$, and $A/2\ \text{cm.}^{-1}$ respectively. If one considers transitions from these 'perturbed' levels to an anti-bonding e^*_g orbital, the counterpart of the bonding molecular orbital constructed from the d_{e_g} orbital of metal atom and the e_g orbital of the ligand, a reasonable explanation of the absorption spectra results. One finds peaks which differ in energies by approximately the amounts which the t_{2g} orbitals are perturbed via spin-orbit coupling. The energy difference between the lowest t_{2g} orbital and the e^*_g orbital (10 Dq) decreases regularly from $OsF_6^{=}$ to $OsBr_6^{=}$, as one would predict due to the decreasing strength of the crystal fields.

Unfortunately, the magnetic results obtained for K_2OsF_6 do not fit a Kotani-type curve, and hence it is difficult to evaluate the spin-orbit coupling constant. It is interesting to note that the visible spectrum of this material differs markedly from that of the others, containing only two bands, one at $50{,}000\ \text{cm.}^{-1}$ and one at $32{,}467\ \text{cm.}^{-1}$ [5], and also that this material is a light yellow compound while K_2OsCl_6 (wine-red) and K_2OsBr_6 (black) are both deeply coloured materials.

It would be interesting to see if other complex ions of the heavier transition metal atoms possess an absorption spectrum which can be explained by the utilization of the spin-orbit coupling concept. These three materials, together with $(NH_4)_2OsBr_6$, are (to our knowledge) the only known examples of paramagnetic substances independent of temperature among the complex ions of the platinum group elements.

The details of the above work and a more complete discussion of the theoretical aspects of the problem will be published soon.

We would like to acknowledge the many helpful discussions with Dr. James Richardson and Dr. J. M. Honig. One of us (A. G. T.) wishes to acknowledge the financial assistance of the Purdue Research Foundation and the Research Corporation for the years 1956 and 1957.

ALMON G. TURNER, JUN.
ALAN F. CLIFFORD
Department of Chemistry,
Purdue University,
Lafayette, Indiana.
Sept. 16.

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An Anodal Threshold Phenomenon in the Squid Giant Axon

THE action potential of nerve or muscle is an all-or-none response when preceded by a critical decrease in transmembrane potential. Previous investigations[1–3], on the other hand, have indicated that for hyperpolarization by anodal (inward) currents the membrane's properties are a continuous function of current. I wish to report, however, that in a potassium-enriched medium the squid giant axon displays a discontinuous rise in membrane potential for a sufficiently intense anodal current and that this behaviour is, in several respects, similar to that of the action potential.

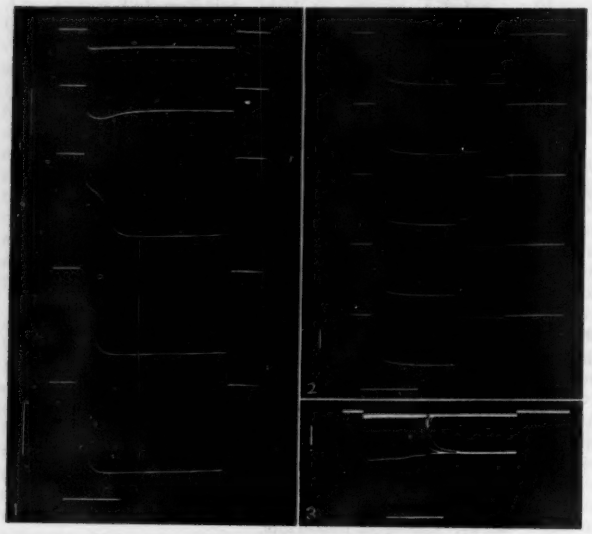

Fig. 1. Changes in transmembrane potential associated with increasing intensities of anodal current. Reading from top to bottom, the current densities (m.amp./cm.^{2}) are 0·079, 0·110, 0·115, 0·120, 0·126, respectively. The vertical and horizontal bars subtend 50 mV. and 50 msec., respectively. Axon No. 1; temperature, 21° C.

Fig. 2. Application of short cathodal pulses of increasing (top to bottom) intensities during a suprathreshold response. The vertical and horizontal bars subtend 50 mV. and 50 msec., respectively. Axon No. 2; temperature, 22° C.

Fig. 3. Composite record made during repetition (1/sec.) of 130 msec. anodal pulse superposed upon which is a brief anodal pulse (see text for details). The vertical and horizontal bars subtend 50 mV. and 50 msec., respectively. Axon No. 3; temperature, 21° C.

The present results were obtained from axons immersed in a solution of 400 mM potassium acetate, 0·6 mM potassium bicarbonate, and sufficient sucrose to maintain tonicity. Fig. 1 shows the change in transmembrane potential recorded at the midpoint of a 17-mm. length of axon across the membrane of which pulses of various intensities of anodal current were passed. A graph of steady-state potential as a function of current consists of two distinct straight lines both extrapolating close to the origin, indicating that for the present medium the threshold change is a discrete decrease in membrane conductance (in the case illustrated the ratio is 0·29 : 1). A long relative refractory period (associated with an increase in conductance relative to that of the resting membrane) follows the 'excited' state: repetitition of the same pulse within a period of less than 1½ min. fails to elicit the suprathreshold response (there is no such refractoriness for subthreshold currents).

That this response represents a discontinuity in the current-voltage (I–V) relationship (when examined with pulses of constant current) and not merely a region of high dV/dI is illustrated by Figs. 2 and 3, in which short cathodal and anodal pulses, respectively, superimposed on the main response, are compared.

It can be seen that following the cathodal pulse the potential is stable at only one of two levels—the transition zone is 'forbidden'. (For cathodal currents the steady-state I–V curve contains no discontinuity and it is not possible to abolish a maintained depolarization with a short anodal pulse.) An analogous phenomenon for the normal threshold response (abolition by application of short anodal pulses during the action potential) has been described for the node of Ranvier[4], for the squid axon injected with tetraethylammonium chloride[5], and for cardiac muscle[6].

The converse property is demonstrated by the experiment of Fig. 3, which shows (in a composite record of approximately ten traces) the effect of the repetition (1/sec.) of a 1-msec. anodal pulse superposed midway during a 130-msec. anodal pulse (both pulses were of approximately the same intensity and were not altered during the train). The largest prolonged downward deflexion is the potential recorded during the application of the first pulse of the sequence. The smaller prolonged deflexion is the response to each of the next five pulses—the system is refractory. As the refractoriness subsides, the short pulse becomes adequate to elicit (during the remainder of the long pulse) a suprathreshold response as indicated by the two traces with slow rising phases following the end of the short pulse. This, again, demonstrates that the potential cannot be stabilized in the region between the sub- and suprathreshold levels.

A sufficient condition for the above phenomenon is a concentration of potassium greater than normal irrespective of the presence or absence of calcium, sodium, or of chloride.

I am indebted to Dr. I. Tasaki for his provision of laboratory space and for the loan of some equipment. I thank Mrs. I. Tasaki for constructing the electrodes employed in this investigation.

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JOHN R. SEGAL*

Marine Biological Laboratory,
Woods Hole,
and
Department of Biology,
Massachusetts Institute of Technology,
Cambridge, Massachusetts.

Sept. 29.

* Pre-Doctoral Research Fellow of the National Institute of Neurological Diseases and Blindness.

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Formation of Condensed Tannins in Plants

I HAVE presented evidence[1] that leucoanthocyanins are probable precursors of condensed tannins; recent examination of *Schinopsis* spp.[2,3] supports this view (see also ref. 4). It was shown[1] that most of the soluble phenolic materials in the sapwood of *Eucalyptus marginata* were leucoanthocyanins, and that the amount increased at the sapwood–heartwood boundary, where they were changed into the insoluble 'tannins' characteristic of this species. In some samples containing a distinctive outer heartwood zone, this change in solubility was found to be incomplete. Monomeric leucoanthocyanins which yielded delphinidin and cyanidin were found in this zone but were not observed in the inner heartwood.

When the ray and vertical parenchyma cells die at the sapwood–heartwood boundary, increased amounts of tannins appear and are liberated into the surrounding tissues. It is significant, therefore, that the ray parenchyma cells only of Douglas fir contain leucoanthocyanins[5]. This conclusion was drawn from the observation that the contents of these cells rapidly became red on the addition of concentrated hydrochloric acid. However, all the leucoanthocyanins we tested failed to behave in this manner.

We have found that the leucoanthocyanins can be made insoluble if blocks of fresh wood (*Eucalyptus* spp.) are soaked in a mixture of 40 per cent formalin/glacial acetic acid/water (5 : 15 : 80) under vacuum for 18 hr., heated for 1 hr., then boiled in water for 3 hr. When sections from these blocks were heated with butanol/hydrochloric acid (20 : 1) for 40 min., little, or no, formation of alcohol-soluble anthocyanidins occurred. After the sections were mounted in glycerol/water/hydrochloric acid (47 : 47 : 6) the contents of the parenchyma tissue in the sapwood were observed to be bright red; but no evidence of diffusion into the surrounding tissue was seen. Because anthocyanidins were obtained from untreated specimens, and as leucoanthocyanins are almost the only compounds which become red after heating with hydrochloric acid, the colour formed in the treated sections is considered to be due to leucoanthocyanins.

The ray cells close to the cambium were lined with leucoanthocyanins (compare with the phenolic membrane substance of Erdtman[6] and the lining observed by Pew[7]). The contents of the sapwood ray cells were observed to be greater in amount at increasing distances from the cambium, assuming a clearer and brighter red colour. Only in the sapwood adjacent to the heartwood boundary did the vertical parenchyma also contain leucoanthocyanins. At the boundary and in the heartwood the fibres were red and in the case of *Eucalyptus camaldulensis* red inclusions were also observed. Those cells immediately surrounding kino veins in *Eucalyptus obliqua* were filled with leucoanthocyanins, but only small amounts were evident in the ray cells a short distance from the injury. These observations support the views of Bate-Smith and Metcalfe[8] that the materials in their wood sections reacting with iron are most commonly leucoanthocyanins (see also ref. 9) formed *in situ*.

A marked decrease in the amount of glycosides and increase in aglycones has recently been observed after the sapwoods of *Schinopsis*[2], *Prunus*[10] and *Eucalyptus* spp.[11] were changed to heartwoods. It is evident that physiological changes affect the nature of the chemical constituents. The above evidence indicates that the glycoside moieties (and probably other carbohydrates) are metabolized in the living cells of the sapwood, particularly in the region of increased activity at the heartwood boundary. Leucoanthocyanins appear to be a common product of this metabolism. Recently, it was found that the amount of (+)-catechin was much lower in the heartwood than in the sapwood of species which also contained leucoanthocyanins[2,10,12]. Consequently, it seems likely that the condensed tannins in many woody plants are formed by the polymerization of leucoanthocyanins, either alone or in conjunction with catechin and other compounds.

W. E. HILLIS

Division of Forest Products,
Commonwealth Scientific and
Industrial Research Organization,
Melbourne.

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Electron Spin Resonance Investigations of Rat Liver and Rat Hepatoma

STUDIES concerning the role of free-radical reactions in biological processes have long been hampered by the lack of a method for detecting free radicals in biological systems. The recent investigations of Commoner[1] have shown that electron spin resonance techniques offer considerable promise for this purpose. This communication describes, first, an investigation of sample preparation and handling methods, and second, a qualitative comparison of electron spin resonance signal intensities from normal rat liver tissue with Novikoff rat hepatoma.

Measurements were carried out at 9,000 Mc./s. using a magnetic field of 3,200 gauss. The g values observed were almost identical with that of the free electron. The size of all samples was approximately 1·7 gm. The free radical contents were inferred from measurements reflecting the area under the absorption curve, which is proportional to the free radical content of the samples studied.

Table 1 shows that freeze-dried rat liver samples contain about five times as many free radicals per unit weight of living tissue as samples chilled to − 196° C. instantly upon excision of the liver and examined in the electron spin resonance spectrometer without allowing the sample temperature to exceed − 130° C. at any time. Since the electron spin resonance line width of freeze-dried samples was found to be less than that of the instant-frozen samples, it is possible that the free radicals created during the freeze-drying process are artefacts, completely different from those originally present in frozen, but otherwise unaltered, material. This conclusion is supported by the fact that Miyagawa and Gordy *et al.*[2] have found that the electron spin

Table 1. Free-Radical Content of Rat Liver and Hepatoma obtained from Electron Spin Resonance Measurements carried out at −130° C.

Sample type	No. of samples	Free-radical content in molecules × 10^{9}/gm. wet weight*
Freeze-dried rat liver	2	10
Immediately frozen rat liver	3	1·9
Rat liver stored at 0–25° C. from 22 hr. to 2 weeks	3	1·3
Immediately frozen rat hepatoma	3	0·67

* Values given are based on an estimate of the electron spin resonance spectrometer sensitivity obtained using a 6×10^{-4} gm. diphenylpicrylhydrazil sample for calibration.

resonance signal from lyophilized tissue arises from sorbed molecular oxygen.

Although storage of the unaltered samples at 0–25° C. causes a reduction in electron spin resonance signal strength compared with that observed for instantly frozen samples (Table 1), no significant difference in signal amplitude was found for storage periods ranging from twenty-two hours to two weeks. Therefore, the conclusion is that some of the free radicals initially present in the instantly frozen samples are unstable at room temperature; the remainder appear to be extremely stable.

Quite possibly part of the observed electron spin resonance signal (particularly that part which is stable at room temperature) observed in frozen liver tissue is caused by the presence of certain paramagnetic trace elements. From the careful investigations of Heggen and Strock[3] it is concluded that for those paramagnetic ions exhibiting a g value close to 2·00, only one or two trace elements occur in large enough concentrations to contribute to the signal. However, more work is being carried out at the present time to determine to what extent such ions are affecting the signal intensities.

Investigations of hepatoma tissue were carried out using Novikoff tumour transplant material originally induced by use of diacetylaminofluorene. As seen from Table 1, the free-radical content of instantly frozen rat hepatoma is only roughly one-third of that found in similarly processed normal liver.

Thus, the number of unpaired electrons observed in frozen samples is much lower than that obtained for freeze-dried specimens. The differences in signal strength between instantly frozen rat liver and rat hepatoma is much greater than that reported by Commoner[1], who used the freeze drying process.

We wish to acknowledge many helpful discussions of this material with William H. Storey, jun., and George Pish. Dr. Karl Paschkis, of Jefferson Medical College, kindly supplied the rats having tumours.

Frank K. Truby

Physics Department,
Southwest Research Institute,
San Antonio, Texas.

Joseph W. Goldzieher

Southwest Foundation for Research and Education,
San Antonio, Texas.

Aug. 25.

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Detection of Polarization by Biological Organisms

For the construction of colour filters Christiansen[1] had the idea of using scattering to attenuate unwanted wave-lengths. He used a finely divided isotropic scatterer in an isotropic medium to achieve partial monochromatization. One of us (A. N. F.), in connexion with a Science Fair project on these filters, suggested the use as a scatterer of a bundle of parallel transparent birefringent fibres immersed in an isotropic medium the refractive index of which matched one of the refractive indices of the fibres. Light vibrating in a direction characterized by this index will then be transmitted unattenuated by scattering. A Patent Office search reveals a number of patents involving scattering to attenuate unwanted components[2]. However, there seems to be no recognition of this method of achieving polarized light in the scientific literature. These patents seem to have been largely overlooked.

There are a large number of papers devoted to the responses to polarized light of various biological organisms[3]. In most cases, the method used to determine the plane of polarization is not known.

We wish to suggest that the above-mentioned polarizing mechanism may well play the necessary part in such determination. Animal tissues often contain bundles of parallel transparent birefringent fibres immersed in a liquid or gel medium. If the index of refraction of the medium is other than the average of the two refractive indices of the fibres, then any transmitted light will be partially polarized. If it matches one of the refractive indices, then that component will be a maximum in intensity. We intend to search for such polarizers.

Arthur N. Fankuchen

Stuyvesant High School,
New York.

I. Fankuchen

Polytechnic Institute of Brooklyn,
Brooklyn, New York.

Aug. 21.

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Stable Test-Papers for Seminal Acid Phosphatase

The acid phosphatase test has proved its usefulness in seminal stain examinations and is now in widespread use[1–4]. The desirability of preparing a stable form of the reagent was obvious, more especially for 'scene-of-crime' searching, post-mortem examinations and for scientists and clinicians without laboratory facilities.

We have prepared stable test papers as follows.

200 mgm. α-naphthyl phosphoric acid and 400 mgm. diazo-*o*-dianisidine (as 'Brentamine Fast Blue *B* Salt', Imperial Chemical Industries) are dissolved in 100 ml. *M*/5 citric acid/sodium citrate buffer of *p*H 4·9. Filter papers soaked in this solution are immediately blotted and left to dry singly at room temperature. These manipulations are best carried out in light of low intensity. The papers are

then stored in opaque bottles at room temperature over calcium chloride. In use the papers are wetted with distilled or tap water and pressed against the suspected seminal stain. A positive reaction is shown by an intense purplish colour.

Discoloration on storage proceeds only slowly and we have found the papers to be usable up to a year from manufacture, with a little activity remaining up to two years (storage temperature 15° C. ± 5° C.). Storage at 55° C. for some weeks is possible, showing that temperature will not be a limiting factor for use in tropical countries.

A modification of the test is to interpose wet filter paper between the stain and the test-paper instead of placing them in direct contact. This possesses the advantage of reducing contamination of the seminal stain by the reagent (this is especially important where serological tests are afterwards to be applied): it permits also the use of test papers which, although discoloured by long storage, are still usable. This is because extracts from the stain and test paper pass into the clean filter paper and react there. The insoluble coloured decomposition products remain on the test paper.

S. S. KIND

Home Office Forensic Science Laboratory
(N.E. Area),
Haddon Lodge,
Rutland Drive,
Harrogate, Yorkshire.
Aug. 25.

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Detection of Hæmoglobin, Hæmoglobin–Haptoglobin Complexes and other Substances with Peroxidase Activity after Zone Electrophoresis

HÆMOGLOBIN and complexes of serum haptoglobins with hæmoglobin, have peroxidase-like activity which permits their detection in small amounts. For this purpose benzidine[1,2], *o*-tolidine[2], guaiacol[3] and leucomalachite green[4] have been employed. However, none of these substances has proved entirely satisfactory. The colours given by benzidine and tolidine fade within minutes[5], especially when applied to starch-gel strips, and both reagents give appreciable background staining on paper. Instability of benzidine and guaiacol colours used to detect horse-radish peroxidase after paper electrophoresis has been noted also by Jermyn and Thomas[6], who reported that *o*-anisidine, *p*-aminodimethylaniline and hydroquinone were even less satisfactory as reagents for the detection of peroxidases. Malachite green, formed from leucomalachite green, is more stable; but we have found the reagent much less sensitive than either benzidine or tolidine.

In studying the haptoglobins of human serum we have sought a more satisfactory peroxidase colour reaction and have compared a number of likely substances. The reagents in each case were prepared by dissolving 100 mgm. of the test substance in 70 ml. of ethanol and adding 10 ml. of 1·5 *M* acetate buffer (*p*H 4·7) and 18 ml. of water. Immediately before use 2 ml. of hydrogen peroxide (100 vol.) was added. The composition of the reagents was thus similar to the benzidine reagent used by Moretti *et al.*[1]. After electrophoresis, paper or starch-gel strips were placed in the reagent for 15 min. and were then washed in three changes of water.

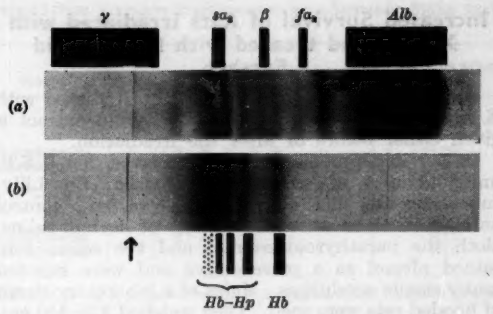

Fig. 1. Starch-gel electrophoretic strips (borate buffer, *p*H 8·6; ref. 7) of human serum containing added hæmoglobin. *a*, stained with naphthalene black to show proteins; *b*, stained with dianisidine reagent to show hæmoglobin–haptoglobin complexes and photographed after 2 weeks. *Hb*, hæmoglobin; *Hb–Hp*, hæmoglobin–haptoglobin complex. Arrow indicates point of insertion

Results are shown in Table 1 and indicate that *o*-dianisidine was the most satisfactory reagent. It gives an intense brown colour in zones having peroxidase activity. After washing and drying, the reactive areas on paper become brown-pink while the paper shows a very pale pink background. In starch-gel strips the coloured areas remain unaltered for at least a month while the background remains perfectly white. Fig. 1 illustrates a starch-gel electrophoresis strip of human serum containing added hæmoglobin.

Table 1. COMPARISON OF PEROXIDASE REAGENTS

Substance*	Sensitivity† (10^{-3} μgm./cm.²)	Comment
o-Dianisidine	5	Colour stable
o-Tolidine	10	Marked background colour fades in hours
Benzidine	20	Colour fades in minutes
p-Anisidine	40	Colour fades in minutes
Amidopyrine	>80	—
Leucomalachite green	>80	—
Guaiacol	>80	—

* All materials were obtained from British Drug Houses, Ltd.
† Minimal concentration of hæmoglobin detectable on paper.

While most of our experiments were carried out with hæmoglobin or with hæmoglobin–haptoglobin complexes, we have also found the dianisidine reagent satisfactory in the detection of peroxidase activity in extracts of horse-radish (*Cochlearia armoracia* L.) and other plants.

We should like to thank Miss Hania Ayzner for technical assistance in this investigation.

J. A. OWEN
H. J. SILBERMAN
C. GOT

Department of Biochemistry,
University of Melbourne,
Carlton, N.3,
Victoria.

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Increased Survival of Rats irradiated with X-Rays and treated with Parathyroid Extract

An increase in the survival of rats irradiated with X-rays has been found when parathyroid extract is given either before or after the irradiation.

In our experiments, each rat received 200 U.S.P. units (2 ml.) of parathyroid extract (Eli Lilly) subcutaneously in the dorsothoracic region; control animals received an equal volume of normal saline. Both the parathyroid extract and the saline contained phenol as a preservative and were injected under sterile conditions. Males of a laboratory strain of hooded rats were used. They weighed 275–350 gm. at the beginning of each experiment. In one series, injections were given 12–18 hr. before irradiation. In a second series, animals were injected immediately after irradiation. All animals received 760 r. whole-body irradiation (measured in air) with 2,000 kVp. X-rays (1·5 m.amp.). This dose was given 65 cm. from the target at 400 r./min. No filters were used. Food and water were given *ad libitum* during the post-irradiation period.

When parathyroid extract was injected before or after irradiation, a difference was observed between the percentage surviving in the control and treated animals. By 20 days, this difference became highly significant (Table 1).

Table 1. Effect of Parathyroid Extract on the Number of Rats surviving 760 r. Whole-body Irradiation with X-Rays

	Days after irradiation						Percentage surviving (30 days)
	0	10	15	20	25	30	
Pretreatment (12–18 hr. before irradiation)							
Saline (2 ml.)	119	117	94	74	68	63	52·9
Parathyroid extract (2 ml.)	119	118	109	102	98	97	81·5*
Post-treatment (immediately after irradiation)							
Saline (2 ml.)	56	50	23	14	12	12	21·4
Parathyroid extract (2 ml.)	54	51	41	38	37	36	66·7*

* $P < 0·001$ (chi-square)

When parathyroid extract was injected before irradiation, survival at 30 days irradiation was 52·9 per cent in the controls and 81·5 per cent in the treated animals (Table 1). When injections were given after irradiation, survival was 21·4 per cent in the controls and 66·7 per cent in the treated rats. This represents an increase in survival of 28·6 per cent and 45·3 per cent for rats injected with parathyroid extract before and after irradiation, respectively. These differences were highly significant ($P < 0·001$).

Between 30 and 60 days, the difference between the percentage surviving in the controls and treated animals was still evident, although slightly reduced. The percentage surviving in the controls was 51·3 and in the treated rats was 73·1, when treatment was administered before the irradiation. In rats injected after irradiation, the corresponding percentages at 60 days were 16·1 and 57·4.

It is not clear why fewer animals survived in the control group injected with saline immediately after irradiation (21·4 per cent) than in the controls injected before irradiation (52·9 per cent) (Table 1). However, a much greater proportion of gastro-intestinal hæmorrhage occurred in the animals which died in the series injected after irradiation. This may have been the cause of the difference.

We conclude that the parathyroid extract used protects against radiation death. Experiments are in progress to determine whether this effect is a result of the activity of the hormone (that is, its ability to increase serum calcium[1]) or to some other property of the extract.

R. H. Rixon
J. F. Whitfield
T. Youdale

Biology Branch,
Atomic Energy of Canada, Limited,
Chalk River, Ontario.

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Protective Action of Venoms containing Phosphatidase-*A* against Certain Bacterial Exotoxins

We reported recently that a fraction of venom of the Australian tiger snake (*Notechis scutatus scutatus*), rich in hæmolysin, protects mice against both the dermonecrotic and lethal action of staphylococcal alpha toxin. Such an effect is observed when this fraction of the venom is injected either together with the toxin or separately[1].

Further work has shown that protection is not afforded by the crude venom of the tiger snake, nor by a fraction of the venom rich in neurotoxin but poor in hæmolysin. On the other hand, we have observed that the crude venom of the Australian black snake (*Pseudechis porphyriacus*), of the king brown snake (*Pseudechis australis*), and of the honey bee (*Apis mellifera*) gives the same order of protection against the lethal action of staphylococcal toxin in mice as does the hæmolysin-rich fraction of the venom of the tiger snake. The former three venoms, like that of the tiger snake, are strongly hæmolytic, all containing the enzyme phosphatidase-*A* (Doery, H. M. D., unpublished work). Unlike the venom of the tiger snake, however, they are not powerfully neurotoxic.

By toxoiding the hæmolysin-rich fraction of the venom of the tiger snake with 0·2 per cent formalin, the ratio of the resultant toxicity to the protective power was reduced from that of the untoxoided material. A notable protection against the lethal action of staphylococcal toxin was obtained with this toxoided fraction when it was administered up to 30 min. after the staphylococcal toxin.

Further, we have observed that both this toxoided fraction of tiger-snake venom and non-toxoided crude bee venom protect mice against intraperitoneal challenge with living staphylococci, the virulence of which was enhanced by Boake's[2] method (Table 1). This finding supports evidence that death following the intraperitoneal injection of mice with such living challenge is due to the production of alpha toxin (North, E. A., unpublished work).

It is known that the products of the action of phosphatidase-*A* on lecithin are a fatty acid and lysolecithin. Further, it was shown many years ago that soaps of certain long-chain fatty acids neutralize a number of bacterial toxins *in vitro*[3].

We have confirmed these findings as regards staphylococcal alpha toxin, tetanus toxin and diphtheria toxin using either sodium oleate or sodium linoleate. We have failed to demonstrate protection with the soap of the corresponding saturated acid, sodium stearate. In addition, we have observed that

Table 1. PROTECTION OF MICE AGAINST INTRAPERITONEAL CHALLENGE WITH LIVING VIRULENT STAPHYLOCOCCI BY A TOXOIDED TIGER SNAKE VENOM FRACTION AND CRUDE BEE VENOM

Test	Protective agent	Treatment when given in relation to challenge	Route	Day of death	Survivors after 7 days
1	Nil (controls)	—	—	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	4/20
	0·02 mgm. toxoided tiger snake venom fraction	75 min. before	Subcutaneous	1 1 1 2 3 4 5	13/20
	,, ,, ,,	45 min. after	Intravenous	1 1 1 1 1 1 1 1 1 1 3 3 7	7/20
2	Nil (controls)	—	—	1 1 1 1 1 1 1 1 1 1 1 1 1 3	2/15
	0·02 mgm. toxoided tiger snake venom fraction	95 min. before	Subcutaneous	1 2 2 4 4 5 5	8/15
	1/40 of one bee sting	100 min. before	Subcutaneous	1 1 1 1 2 4 4 7	7/15

All mice were challenged intraperitoneally with 1 ml. of a suspension of living coagulase-producing *Staphylococci* the virulence of which was enhanced by Boake's (ref. 2) clotting mixture.

protection against the lethal action of staphylococcal toxin in mice may be afforded by sodium oleate administered separately. Evidence has also been obtained that the hæmolysin-rich fraction of the venom of the tiger snake is antagonistic to the action of tetanus toxin in mice.

These observations suggest a possible defence mechanism against *in vivo* action of certain bacterial toxins. Phosphatidase-*A* [4] and lysophosphatides[5,6] have been reported to exist in animal tissues as such. Long-chain fatty acids may be liberated from phosphatides in cell envelopes as a response to the action of these toxins. The nature of the suggested interaction between the bacterial toxins and the fatty acids is not understood. This work is being reported in detail elsewhere.

E. A. NORTH
HAZEL M. DOERY

Commonwealth Serum Laboratories,
Parkville, N.2,
Victoria, Australia.
Aug. 19.

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Comparison of the Effect of Ultra-violet and X-rays on the Capillaries of the Frog's Web

THE web between the toes of the frog is very suitable for the examination of the primary processes in the skin after irradiation with ultra-violet light, since the very thin corneal layer permits the entry of ultra-violet light of short wave-length. The transparency is measurable and makes possible the estimation of the absorption at different wave-lengths. To compare the effects of different wave-lengths, knowledge of the absorption coefficient at the site of biological action is necessary.

Transparency measurements were carried out in the range 280–600 mμ; below 280 mμ there was no transparency. The thickness of the layers (stratum corneum on each side, its layer of compensation, Malpighian layer and the dermis in the centre) was determined in histological cross-section. We were unable to detect a significant change in the absorption coefficient for the different layers, and therefore no influence of the histological structure was observed.

Fig. 1 shows average percentage of the applied radiation absorbed by a layer 1μ thick plotted against the depth of the layer. The diameter of the field measured was 2·4 mm. Ultra-violet irradiation was supplied by a high-efficiency monochromator with a high-pressure mercury lamp[1], *HBO* 2001. The radiant flux density was measured with a bolometer.

The reactions of the blood circulation to irradiation have been studied by Giersberg and Hanke[2] and by Bücker and Hanke[3]. Together with histological effects and changes in transparency with the changing water-content of the layers, the flow of blood was blocked even though the width of the vessels remained constant. The doses which produced this effect in 50 per cent of the animals were 10 watt sec. cm.$^{-2}$ (280 and 297 mμ) and 35 watt sec. cm.$^{-2}$ (313 mμ). 366 mμ had no effect. The absorption per layer 1μ thick was 0·3 per cent at 280 mμ (Fig. 1), 0·58 per cent at 297 mμ and 0·69 per cent at 313 mμ in the region of the capillaries on the irradiated side. The relative efficiency of the different wave-lengths

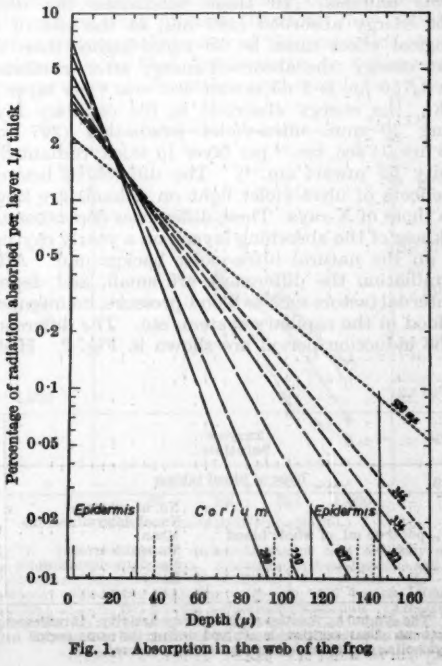

Fig. 1. Absorption in the web of the frog

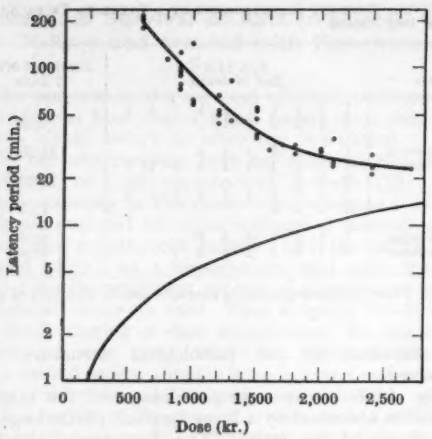

Fig. 2. Dependence of latency period on dose (upper curve). Dose-rate 200 kr./min. Curve below shows irradiation times

280, 297 and 313 mμ was 1 : 1·9 : 8. It is evident that the capillaries or their neighbourhood are the site of the primary effect.

After irradiation with X-rays ('Dermopan' apparatus, 45 kV., 25 m.amp., beryllium window, 35 mm. from tube axis, 200 kr./min.), blockage in the capillaries occurred only, after a latent period, within the limits of the irradiated field. The effect was caused by a dose of 600 kr. and more. The latent period decreases exponentially with the dose. The differences in Fig. 2 at high doses result from the longer irradiation times. The effect after X-irradiation with 1,750 kr. occurs 30 min. after the start of irradiation. Ultra-violet irradiation (297 mμ) requires a radiant flux-density of 55 mwatts cm.$^{-2}$ during 30 min. to produce stasis in 50 per cent of the animals. In these conditions the ultra-violet energy absorbed (297 mμ) at the site of its biological effect must be 35 times higher than the X-ray energy (the absorbed energy after irradiation with 1,750 kr. is 1·63 mwatt sec. cm.$^{-2}$ per layer 1μ thick; the energy absorbed in the capillary layer during 30 min. ultra-violet irradiation (297 mμ) is 58 mwatt sec. cm.$^{-2}$ per layer 1μ thick, radiant flux density 55 mwatt cm.$^{-2}$). The differences between the effects of ultra-violet light on animals are larger than those of X-rays. These differences depend on the thickness of the absorbing layers, on a yearly rhythm, and on the natural ultra-violet background. After X-irradiation the differences are small, and depend on internal factors such as blood-pressure, maintenance of blood in the capillary system, etc. The differences in the induction period are shown in Fig. 2. Histologically there are some differences between the effects of the two kinds of rays which we used[4].

Horst Bücker
Wilfried Hanke

Max-Planck-Institut für Biophysik,
Zoologisches Institut der Universität,
Frankfurt-am-Main.
Sept. 8.

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Biochemical Basis of Disturbances caused by Thermal Stress in the Central Nervous System of Man

Investigations on men subjected to thermal stress showed characteristic changes in behaviour as well as disturbances in higher nervous activity. Thermal stress at first causes increased excitability of the central nervous system, the subjects showing an augmented mobility, a vivid interest in their environment and a marked loquacity. Later, this condition undergoes a change and the subjects fall into a state of drowsiness (without, however, any tendency to sleep) and apathy[1]. Measurements of the conditioned reflex-[2] and serial reaction-time[3] revealed changes of these values under the influence of environmental high temperature.

This investigation aimed at determining the biochemical events by which such disturbances in the functions of the central nervous system are caused. Two enzymes present in blood, namely, acetylcholinesterase (true cholinesterase) of erythrocytes and cholinesterase (pseudo-cholinesterase) of plasma were investigated. The first of these enzymes is identical, or almost identical, with the acetylcholinesterase present in the central nervous system[4]. Establishment of changes in the activity of this enzyme, so important in conduction and transmission processes, could serve as at least a partial interpretation of the disturbances caused by thermal stress.

The second enzyme investigated, pseudo-cholinesterase, is present in many tissues. Its presence, among others, in the autonomic ganglia indicates a connexion with the functions of the autonomic part of the nervous system. Its exact role therein, however, is unknown. The activity of pseudocholinesterase has been investigated for the present only to detect changes caused by thermal stress.

The investigations were carried out on 50 male subjects aged between 20 and 47 years. The subjects were medically examined and considered to be healthy. The subjects were placed, naked and

Table 1

Enzyme: Substrate:		Acetylcholinesterase of erythrocytes Acetyl-β-methylcholine		Cholinesterase of plasma Butyrylcholine	
Time of blood taking		Before stress	After stress	Before stress	After stress
b_{20} per 0·05 ml. of whole blood	No. of subjects	50	50	50	50
	No. of determinations	100	100	100	100
	Mean	76·1	77·2	29·9	30·6
	Standard error	± 2·3	± 2·3	± 0·7	± 0·7
	Standard deviation	± 16·5	± 16·2	± 5·1	± 5·1
	Range	52·1–137·1	51·0–132·9	10·0–42·1	13·5–44·0

The symbol b_{20} denotes cholinesterase activity. It indicates the amount of carbon dioxide (μl.) evolved during the period of 30 min. minus the amount of carbon dioxide evolved during the same period by spontaneous (non-enzymatic) hydrolysis of the substrates (four for acetyl-β-methylcholine and three for butyrylcholine) (see ref. 7).

stretched out on the wooden floor at complete rest for 2 hr., in a climate chamber which has been described by Dutkiewicz *et al.*[5]. The activity of both enzymes was estimated with the gasometric technique exactly as described by Augustinsson[6]. Acetyl-β-methylcholine chloride ('Amechol', Savory and Moore, Ltd.) was used as substrate for acetylcholinesterase, and butyrylcholine chloride (L. Light and Co., Ltd.) for cholinesterase.

The results are shown in Table 1.

There are no significant differences in the activity of the two enzymes investigated before and after 2 hr. in the climate chamber. The results obtained agree with those of Field *et al.*[7], who also found no changes in the activity of acetylcholinesterase of brain in rabbits with pyrexia.

Investigations of the acetylcholine content in the brain hemispheres of mice exposed to conditions of thermal stress similar to those described above for our human subjects showed no differences in values obtained for animals in normal and in heated atmospheres[8]. If, therefore, it is admissible to compare experimental results obtained for men with those obtained for mice, it appears probable that cholinergic neurones and synapses are not involved in the changes in behaviour and higher nervous activity caused by thermal stress.

We wish to thank Mrs. A. Lewicka for help in performing these experiments.

M. KRAUSE

Institute of Occupational Medicine in the Mining and Metallurgical Industries, Zabrze 8, Rokitnica, Poland.

Aug. 11.

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Effect of 8-Azaguanine on Antibody Synthesis *in vitro*

CREASER[1] has shown that 8-azaguanine is strongly inhibitory to induced enzyme formation in bacteria, but less so to the formation of 'constitutive' enzyme. On the basis of these findings and other evidence[1], Creaser suggested that induced enzyme formation might be mediated by unstable ribonucleic acid templates needing continuous resynthesis, while 'constitutive' enzyme formation might utilize more stable templates.

The concept has been advanced that antibody formation may be analogous to induced enzyme formation (for example, ref. 2). To gain information on this, the effect of inhibition of the incorporation of carbon-14-leucine into antibody protein and into a 'constitutive' spleen cell protein was studied. 8-Azaguanine was taken as an inhibitor particularly of nucleic acid synthesis and *p*-fluorophenylalanine as an inhibitor particularly of protein synthesis.

Spleen cell suspensions were prepared from rabbits three days after an anamnestic injection of egg albumin. The details of this preparation will be described elsewhere[2]. Since the rate of incorporation of carbon-14-leucine into antibody by the spleen cell preparation is linear for at least 24 hr.[3], this period was adopted for the measurement of antibody synthesis. At the end of the incorporation period, radioactive antibody was isolated by co-precipitation with added rabbit anti-egg albumin and egg albumin. Control precipitates, made with an unrelated antigen–antibody system (human γ-globulin–antihuman γ-globulin), yielded less than 4 per cent of the activity found in the test precipitates (egg albumin, anti-egg albumin) (Table 1). The fraction insoluble in trichloracetic acid prepared from the insoluble material recovered from disintegrated cells was used as a 'constitutive' spleen cell protein.

Table 1. THE 24-HR. INCORPORATION OF CARBON-14-LEUCINE INTO ANTIBODY

Radioactivity in medium, c.p.m. ^{14}C-DL-leucine	L-Leucine conc. (μgm./ml.)	No. of cells*	Control γ-globulin, anti-γ-globulin p.pt. Total/c.p.m.	Egg albumin, anti-egg albumin p.pt. Total/c.p.m.
$3{\cdot}9 \times 10^8$	91	6×10^7	310 208	17,400 16,600
$2{\cdot}0 \times 10^8$	59	4×10^7	530 585	14,600 15,300
$0{\cdot}8 \times 10^8$	39	4×10^7	86 89	7,000 7,700

Precipitates were washed twice with 0·85 per cent saline with 2 mgm./ml. carbon-12-DL-leucine.
* 2×10^7 cells approximately equivalent to 10 mgm. wet weight.

As is evident from Fig. 1, isotope incorporation into antibody was sharply inhibited by 8-azaguanine (solid circles). However, there was also a very considerable inhibition of incorporation into the insoluble cell protein fraction (open circles). Furthermore, the same effect was seen with *p*-fluorophenylalanine, which also inhibited incorporation into antibody (solid triangles) more than incorporation into the insoluble fraction (open triangles). *p*-Fluorophenylalanine may be regarded as a general antagonist of protein synthesis, independent in its action of any peculiar lability of a ribonucleic acid template. The differences noted in isotope incorporation into antibody and into cell protein, therefore, may better be attributed to relative rates of the respective protein syntheses rather than, particularly, to differences in turnover rates of ribonucleic acid templates. Consis-

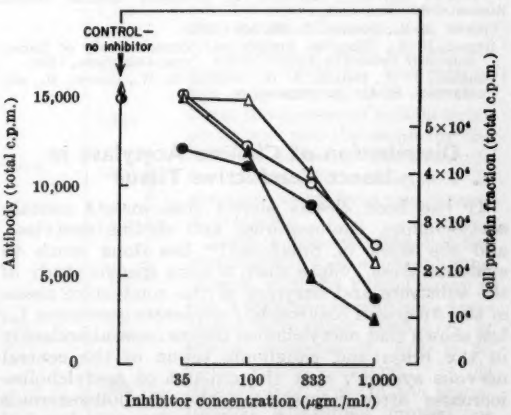

Fig. 1. Incorporation of carbon-14-leucine into antibody and insoluble cell protein fraction. Inhibition by 8-azaguanine and by *p*-fluorophenylalanine. ●—●, Antibody, 8-azaguanine; ▲—▲, antibody, *p*-fluorophenylalanine; ○—○, cell protein 8-azaguanine; △—△, cell protein *p*-fluorophenylalanine. Carbon-14-DL-leucine was added after 1 hr. of pre-incubation with inhibitors. Total counts/min. for antibody and cell protein refer to the totals produced per culture (20 mgm. wet weight)

Table 2. Inhibition of Phosphorus-32-Phosphate Uptake into Phosphate Fractions of the Cell by 8-Azaguanine and by *p*-Fluorophenylalanine

Inhibitor	Percentage of control uptake		
	Acid-soluble organic phosphate	Ribonucleic acid phosphate	Deoxyribonucleic acid phosphate
8-Azaguanine 300 μgm./ml.	70	72	53
p-Fluorophenylalanine 300 μgm./ml.	100	98	81

Cell suspensions were incubated for 1 hr. with phosphorus-32-phosphate after a 4-hr. period of pre-incubation with inhibitor.

tent with this interpretation is the finding (Table 2) that in a concentration (300 μgm. per ml.) at which 8-azaguanine has a 35 per cent inhibitory effect on antibody synthesis (cf. Fig. 1) there is a similar (30 per cent) reduction in phosphate turnover in the acid-soluble phosphate pool. Thus, though 8-azaguanine inhibits antibody formation, this is not an isolated event, but rather a manifestation of a general suppression of spleen cell function.

This tentative interpretation of the spleen cell system, however, is subject to several limitations. Amino-acid incorporation into antibody, made only in a small proportion of the cells, has been compared with amino-acid incorporation into a poorly characterized protein isolated from the whole cell population. Moreover, a considerable fraction of the latter appear to be dying[2]. Finally, in induced enzyme formation, it is the inhibition of the ability to begin making new protein which is measured, whereas, in the present system, it is the inhibition of the ability to continue to make new protein which has been measured.

Further experiments designed to approach these points are in progress. This work was supported by U.S. Public Health Services grant *E*1305.

R. W. Dutton*
Anne H. Dutton*
Mariam George*

Medical College of Virginia,
Richmond 19, Virginia.

* Present address: University of Rochester Medical Center, Rochester 20, New York.

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Distribution of Choline Acetylase in Insect Conductive Tissue

It has been clearly shown that insects contain acetylcholine, cholinesterase and choline acetylase, and the work of Smallman[1-3] has done much to evaluate these. Since then, a more specific study of the substrate and enzymes in the conductive tissue of the American cockroach, *Periplaneta americana* L., has shown that acetylcholine occurs most abundantly in the brain and ganglionic tissue of the central nervous system[4], that the amount of acetylcholine increases after treatment with anticholinesterases when the nervous system shows intense electrical activity[5], and that acetylcholine is found in blood at this time[6]. These facts are compatible with those found for vertebrates.

A further step in the evaluation of the role of acetylcholine has now been taken by determining the distribution of choline acetylase in conductive tissue of the cockroach. This work was carried out with homogenates of tissues, as more purified enzyme preparations required impractical amounts of tissue. The activity of choline acetylase of homogenates was determined by the amount of acetylcholine formed in incubates containing coenzyme *A*, acetyl phosphate, transacetylase, choline, salts and buffer (Mehrotra, K. N., and Chefurka, W., private communication). The rate of acetylcholine formation was linear for the incubation period of 15 min., and all work was carried out at 30° C., the experimentally determined temperature optimum for choline acetylase from both cockroach and housefly. This optimum is close to that found for insect eggs (Mehrotra, K. N., and Chefurka, W., private communication). Table 1 shows the rates of acetylcholine synthesis for nervous and muscle tissue. It is at once evident that the brain and thoracic ganglia contain the highest amount of choline acetylase. The results for the distribution of choline acetylase are striking, for they compare favourably with the distribution of acetylcholine[4] in the same tissues. Furthermore, the intracellular distribution of choline acetylase appears to be similar to that found for acetylcholine. At tissue weights equivalent to and in excess of that for nervous tissue, no synthesis was found in cockroach leg muscle. This observation is of interest for, as yet, no detectable amount of acetylcholine has been found in denervated cockroach muscle[7]. The synthesis-rate for cockroach brain is the highest yet reported for acetylcholine synthesis in either vertebrates or invertebrate conductive tissue.

Table 1. Synthesis of Acetylcholine by Choline Acetylase of Cockroach Conductive Tissue

Tissue	Rate of acetylcholine synthesis (mgm./gm./hr.)
Brain	50·6
Brain + sub-œsophageal ganglion	53·0
Ganglia of thoracic nerve cord	20·8
Sixth abdominal ganglion	18·0
Thoracic nerve cord	11·4
Ventral nerve cord	10·6
Abdominal nerve cord	6·2
Connectives of the thoracic nerve cord	2·6
Fifth leg nerve	2·0
Coxal muscle	0
Flight muscle	0

The importance of the functional role of acetylcholine in insects must be considered in view of this evidence for the occurrence and distribution of acetylcholine and related enzymes in the nervous system of the cockroach, and the lack of evidence for physiologically significant amounts of other neurohormones. The details of this work and observations on the tissue distribution of cholinesterase will be published more fully elsewhere.

E. H. Colhoun

Science Service Laboratory,
Canada Department of Agriculture,
University Sub Post Office,
London, Ontario.
Aug. 27.

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Metabolic Alteration in Leukæmia induced by a Virus

RECENT publications[1,2] reporting the induction of leukæmia in mice by cell-free extracts have reawakened general interest in the role of viruses as oncogenic agents and, as a corollary, in the metabolic alterations induced by these agents. It has been shown in this laboratory that alterations in host cell metabolism induced by virus can be detected very soon after infection[3]. The current investigation was undertaken to see if analogous effects could be observed *in vivo* using one of the viruses inducing tumours. The agent investigated here was that described by Friend[2] as producing a leukæmia in mice, characterized by splenomegaly and an accumulation in the spleen of stem cells. The basic experiments were performed as follows: 150 mice were infected i.v. with 0·2 ml. of a cell-free filtrate from spleens of mice carrying the infection. 150 control mice received the same amount of cell-free filtrate prepared from normal spleen. Beginning the day after inoculation of the virus, and at the intervals thereafter indicated in Fig. 1, six infected and six control mice were selected at random and given intraperitoneal injection of 5 μc. of phosphorus-32. 3 hr. later the spleens of these animals were removed, weighed, dried in pre-weighed planchets, reweighed, the radioactivity determined, and expressed as c.p.m./mgm. dry tissue. The averaged wet-weights of the spleens from a typical experiment as well as the averaged c.p.m./mgm. dry spleen are given in Fig. 1. As part of the same experiment, on the fifth day some of the control and the infected mice received 300 r. of total body X-irradiation. The results for weight and radioactivity of the spleens of these mice examined on subsequent days are also included in Fig. 1.

It can be seen that even before spleen enlargement, the spleens in the infected animals took up more radioactive phosphorus than did those in the controls. This has been observed in four out of four experiments performed. Some variation occurred in the day-to-day uptake of phosphorus-32 by the spleens, but in the many (more than 40) observations made, the infected ones always had a higher radioactivity (as c.p.m./mgm.). The statistical significance was usually quite high; in the experiment reported here the P values for the differences between control and infected spleen uptakes was 0·005 or better. The administration of X-rays decreased the size of the infected spleens to normal, so that one could not have detected disease on the basis of spleen size alone. The uptake of phosphorus-32 was decreased in both the infected and control spleens. However, the differential between infected and their controls was as great as it was in the non-irradiated animals.

In other experiments 1 mgm. of cortisone was administered daily intramuscularly instead of X-rays. As with X-rays, the infected spleens returned to normal size, but their subsequent uptake of phosphorus-32 was accelerated over the controls as much as in those without cortisone.

In order to get some information about the specificity of the acceleration of phosphorus-32 uptake, several other diseases involving the spleen were studied in a comparable way. The disease and the uptake of phosphorus-32 by the spleens of these animals are given in Table 1. For reasons not relevant to these observations, the amount of radioactivity given was not the same for the different diseases. This accounts for the marked differences in absolute count from one disease to the next.

Table 1 demonstrates that the stimulated uptake of phosphorus-32 seen with the Friend agent is not a general phenomenon associated with spleen pathology or spleen enlargement, but is to some extent specific. It is striking that none of the transplanted leukæmias showed an increased phosphorus-32 uptake, while the spontaneous leukæmia and the other virus-induced leukæmia did. It should be recalled that some previous work

Table 1. EFFECT OF VARIOUS PATHOLOGICAL CONDITIONS ON UPTAKE OF PHOSPHORUS-32 BY SPLEENS

Condition	Average wet spleen weight		C.p.m./mgm. dry spleen weight		Percentage change
	Infected	Control	Infected	Control	
1. Lymphocytic choriomeningitis (inoculated i.p.)	116	127	248	218	14
2. Histoplasma capsulatum	503	247	285	248	13
3. Lymphocytic leukæmia transplanted	263	68	640	945	−35
4. Leukæmia *P*-195 (Hodgkin's-like), transplanted	613	187	62	62	0
4. Leukæmia *HE*-11,764 *G*-4, transplanted	154	147	49	44	11
4. Spontaneous AKr leukæmia	415	75	123	67	83
5. Gross virus-induced leukæmia	751	57	543	322	69

These animals were kindly supplied by: (1) Dr. Victor H. Haas; (2) Dr. Herbert Hawenclever; (3) Dr. Stephen O. Schwarts; (4) Dr. Lloyd Law; and (5) Dr. Ludwig Gross (ref. 1). At least six experimental and six control mice were used, and in most cases two or three such groups were used. Differences of less than 20 per cent are not considered significant.

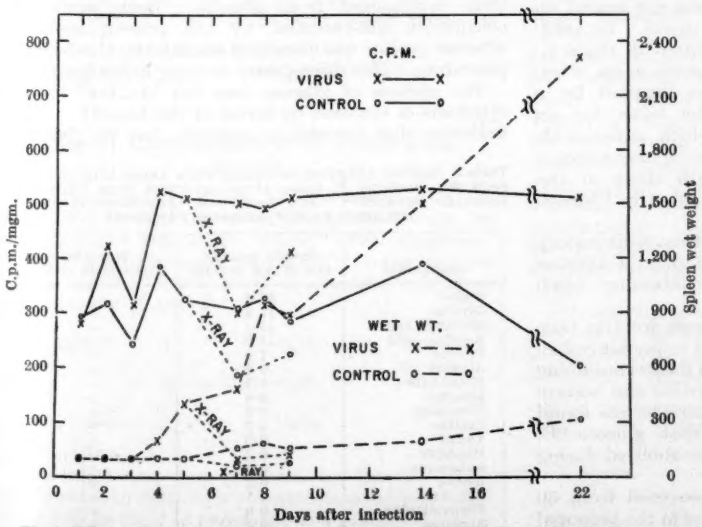

Fig. 1. Effect of Friend leukæmia virus, with and without X-rays, on uptake of phosphorus-32 by spleen

with spleens of mice with transplanted leukæmia indicated that these tissues took up more phosphorus-32 than did normal controls[4]. The experimental procedures were quite different from those used here, and this may account for the differences in results.

With regard to sensitivity to X-rays and cortisone, the Friend leukæmia is like some chronic human leukæmias and lymphomas, whereas the transplanted mouse leukæmias in general are not[5]. With respect to phosphorus-32 uptake, as observed by us, the Friend leukæmia and the Gross virus-induced leukæmia resemble spontaneous mouse leukæmia and are different from the transplanted leukæmias we studied. It might be that the Friend leukæmia would be a valuable disease to use in screening programmes for drugs active against human leukæmia.

We are indebted to LeRoy Snellbaker and William Lane for technical assistance.

Hilton B. Levy
Isadore Brodsky

National Institutes of Health,
National Institute of Allergy and Infectious Diseases,
Laboratory of Infectious Diseases,
Bethesda, Maryland.

Aug. 19.

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Use of Glucose labelled with Carbon-14 to determine the Amino-Acids Essential for an Insect

A chemically defined diet is required for determining essential dietary components by the classical deletion procedure. It has proved difficult to rear plant-feeding insects on artificial diets[1,2]. A method that would permit the determination of essential factors such as amino-acids for insects not reared on chemically defined diets would be useful. In 1952, Steele[3] showed that carbon-14 appeared in the non-essential but not in the essential amino-acids when uniformly labelled sucrose-^{14}C was ingested by a mouse. This finding provides the basis for an indirect method of determining which amino-acids are essential in the diet. The present report compares results of the indirect method with those of the classical deletion procedure[4] for the blowfly *Phormia regina* Meig.

Third-instar larvæ of the blowfly from a laboratory stock colony were injected with 3–6 μl. of a solution of uniformly labelled glucose-^{14}C containing 5,000 counts/min./μl.

The larvæ were maintained on fresh liver in test-tubes placed in a desiccator equipped to permit collections of carbon dioxide in absorption flasks containing suitable solutions of potassium hydroxide and barium chloride. After 24 hr. the carbon dioxide was found to be radioactive. This showed that glucose-^{14}C, when injected into the larvæ, was metabolized during this stage of development.

After 68 hr., 24 insects were recovered from 50 injected larvæ, 13 had pupated, 6 were in the prepupal form, and 5 were still feeding. The insects were homogenized in a Potter-Elvehjem homogenizer first with hot 80 per cent ethanol and then with boiling water. The resulting residue was hydrolysed with 6 *M* hydrochloric acid for 24 hr. and the acid was removed *in vacuo*. The combined extracts were evaporated to dryness. Finally, the dry matters from the extracts and hydrolysate were extracted with water; the solutions were combined and placed on a column of 'Dowex-50' in the H-ion form. The amino-acids were fractionated on the column by first washing with water and then by gradient elution with hydrochloric acid to a final concentration of about 6 *M*[5]. The fractions containing a particular amino-acid, as indicated by paper chromatography and published elution curves[5], were combined, evaporated *in vacuo*, and further purified by band paper chromatography. After development of a band chromatogram the amino-acid was eluted with water, the eluate was concentrated, and chromatographed further. Four solvent systems were used in all cases: *n*-butanol/acetic acid/water (4 : 1 : 5); ethanol/ammonia (95 : 5); water-saturated phenol; and 95 per cent ethanol; further purification of individual amino-acids was made in other solvent systems when necessary.

Amino-acids eluted from final paper strips were dissolved in water and determined quantitatively by a general colorimetric method[6], or by more specific tests for proline[7], phenylalanine[8], arginine[9], histidine and tyrosine[10]. An aliquot of the amino-acid solution containing about 1 μ*M* of the compound was plated on a copper planchet and the radioactivity was determined with a gas-flow counter.

Table 1 shows that serine, glycine, glutamic acid, and aspartic acid, found non-essential by the deletion procedure, all contained the largest quantity of radioactivity. Leucine, threonine, valine, histidine, *iso*leucine, lysine, phenylalanine, and arginine, shown to be essential by the classical method, contained little if any radioactivity. Thus, these twelve amino-acids may be grouped as essential or non-essential according to their labels of radioactivity.

The presence of intermediate quantities of radioactivity in proline and alanine indicates that both were synthesized from glucose. Both would be considered non-essential by the present method, whereas proline was classed as essential by the deletion procedure. This discrepancy is being investigated.

The carbon of glucose was not involved in the synthesis of tyrosine by larvæ of the blowfly. This indicates that tyrosine is essential, but the deletion

Table 1. Specific Activities of Carbon from Amino-Acids Isolated from the Blowfly *P. regina* after Injection with Uniformly Labelled Glucose-^{14}C, and Amino-acid Requirements as determined by the Deletion Procedure

Amino-acid	Specific activity (c.p.m./μ*M* carbon)	Reported requirement (ref. 4)
Serine	22·6	−
Glycine	17·3	−
Glutamic acid	15·1	−
Aspartic acid	14·0	−
Proline	7·9	+
Alanine	3·5	−
Methionine	0·9	−
Leucine	0·6	+
Threonine	0·5	+
Cystine	0·3	−
Valine	0·3	+
Histidine	0·3	+
*iso*Leucine	0·3	+
Lysine	0·2	+
Tyrosine	0·1	−
Phenylalanine	0·0	+
Arginine	0·0	+

method showed that it was non-essential. The essential amino-acid phenylalanine is the principal precursor of tyrosine in the mouse[9] and the silkworm[11]. If this condition exists in the blowfly, then no radioactivity would be expected in tyrosine.

When the amino-acids were individually deleted from a defined diet neither methionine nor cystine appeared to be essential[4]. However, afterwards it was shown by the deletion of two or more amino-acids that *P. regina* required either methionine or cystine in the diet[12]. The low levels of radioactivity in the methionine and cystine isolated from the glucose-injected larvæ agree with the latter results.

The radioactivity method described here gave results for the blowfly *P. regina* that were sufficiently comparable to those of the classical deletion procedure to warrant application to insects that cannot yet be reared on chemically defined diets. There are some discrepancies between the two methods which will need further study. This technique, when applied to the different stages of insects, should provide a means for comparing synthetic abilities during development. Furthermore, the possibility of introducing labelled substrates into insects by other means, such as feeding and vacuum infiltration, will permit the method to be extended. A more complete description of this work along with similar studies using uniformly labelled glutamic acid will be published elsewhere.

R. Kasting
A. J. McGinnis

Science Service Laboratory,
Canada Department of Agriculture,
Lethbridge, Alberta.
Aug. 20.

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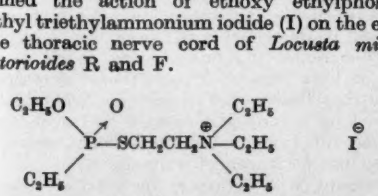
Role of Cholinesterase in Insecticidal Action

Among chemicals allied to the acaricide O,O'-diethyl-S-2-diethylaminoethyl phosphorothiolate, we examined the action of ethoxy ethylphosphinylthioethyl triethylammonium iodide (I) on the enzymes of the thoracic nerve cord of *Locusta migratoria migratorioides* R and F.



(I)

This substance, first prepared by Dr. R. Ghosh of this research station, is a moderate acaricide, being about half as toxic as parathion as a contact spray to *Tetranychus telarius* L. Against the locust it is of low toxicity, the *LD*50 being about 300–500 mgm./kgm. by injection. It is, however, a powerful *in vitro* inhibitor of the cholinesterase of the locust ganglion.

Metcalf *et al.*[1] have suggested that the lack of effect obtained by injection of cholinesters and prostigmine into insects[2,3] can be explained by the highly polar quaternary ammonium compounds being unable to penetrate the insect lipoid nerve sheath or synapses. On the other hand, the very closeness of the structure of this compound to acetylcholine suggests that it might well be broken down by enzymes occurring elsewhere than in the ganglion. Finally, the lack of correlation between toxicity to the locust and anti-cholinesterase activity of certain other non-polar organophosphorus esters[4] throws doubt on the importance of cholinesterase inhibition.

80–100 young virgin adult locusts were injected with 360–720 mgm./kgm. of (I) in buffered saline. Controls were injected with saline only. At intervals, the thoracic ganglia were dissected from a number of the injected locusts as follows: (1) 'Affected', prostrate, incapable of co-ordinated movement, no response to tarsal reflex, but not dead. (2) 'Unaffected', full co-ordination of movement and normal response to reflexes, indicating no interference with synaptic transmission, though, in the early stages, sometimes a little lethargic.

The dissected ganglia from affected, unaffected and controls were washed six times in ice-cold water, then ground in physiological saline (0·02 ml. per ganglion, ~0·02 ml./mgm.), diluted with 0·25 *M* sodium bicarbonate in physiological saline to give a concentration of 2 (in some cases 3) ganglia per Warburg flask. Cholinesterase activity was estimated by the usual Warburg method, involving the development of carbon dioxide from sodium bicarbonate with 0·002 *M* acetylcholine chloride as substrate. Activity measurements were taken over 1 hr. at 37° C.

With an inhibitor as powerful as (I) it is impossible to be certain of even the most meticulous washing method. A minute amount of the chemical left outside the ganglion would be intimately mixed with the enzyme during grinding and an inhibition be obtained *in vitro* which had, in fact, not occurred before dissection. To measure the amount of 'free' inhibitor, an equal amount of ground-up control ganglion homogenate was added to half the 'affected' and 'unaffected' flasks. If any unchanged (I) was present, it would exert its inhibitory power on the control homogenate as well as on the treated. On the other hand, if no free (I) was present, the activity of the mixture should be equal to that of a preparation containing an enzyme as active as the sum of the activities of the two constituent parts. This could be ascertained by the construction of standard curves, and in Table 2 'per cent inhibition' in the case of the mixtures refers to the expected values from these curves.

The validity of the method depends on knowing to what extent doubling the concentration of the enzyme affects inhibition at any one level. To establish this, a number of untreated locusts were dissected, and the

Table 1. Percentage *in vitro* Inhibition for Increasing Enzyme and Constant Inhibitor Concentrations

Concentration of inhibitor (*M*)	Ganglion equivalent in 2 ml.						
	2	3	4	5	6	7	8
1×10^{-9}	89	87	88	91	88	86	87
1×10^{-10}	82	81	79	71	62	65	59
1×10^{-11}	68		37		34		

Table 2. Course of *in vivo* Cholinesterase Inhibition

Experiment C55/34	Hours after injection							
	4		9		13		29	
	Acetylcholine decomposed (μmoles)	Inhibition (per cent)	Acetylcholine decomposed (μmoles)	Inhibition (per cent)	Acetylcholine decomposed (μmoles)	Inhibition (per cent)	Acetylcholine decomposed (μmoles)	Inhibition (per cent)
Affected	0	100	0	100	0	100	0	100
Affected + control	0	100	0·089	93	0	100	0·805	38
Unaffected	0	100	0	100	1·432	18	1·030	21
Unaffected + control	0·134	91	1·300	0	3·310	0	2·820	0
Control	1·478	—	1·255	—	1·748	—	1·300	—
Double control	3·850	—	3·810	—	3·265	—	4·080	—

ganglia homogenized in the usual way. Amounts of homogenate equivalent to 2–8 ganglia were then added to Warburg flasks containing a constant amount of inhibitor.

It appears that if the quantity of (I) is sufficient to inhibit the equivalent of 2 ganglia by about 90 per cent, quadrupling the amount of enzyme produces no significant change. Hence, if the ganglia of treated locusts show complete inhibition, and this was merely an *in vitro* effect produced subsequent to grinding, the addition of an equal amount of homogenate from untreated locusts should still give substantially complete inhibition of the mixture.

Other preliminary experiments have shown that when such an enzyme preparation is added to a solution of (I), the same amount of inhibition is obtained whether all the enzyme is added at once, or in two halves separated by 3 min. on ice. Finally, the slope of the *in vitro* inhibitor concentration/activity curve is such that the experimental dilution cannot affect the general picture. The above procedure would therefore appear to be reasonable.

Table 2 shows the result of a typical experiment. The dose injected was 360 mgm./kgm. and each figure is based on duplicate flasks.

The results of six experiments vary in detail, particularly on a time basis, but show essentially the same picture. While the inhibitor has great difficulty in penetrating the ganglionic sheath, some of it does reach the site of the enzyme and reacts with it. At the time of the first dissection there is an excess of the inhibitor present, resulting in inhibition of the mixtures as well as the affected and unaffected by themselves. At the time of the second dissection there is no further (I) left in the unaffected, the mixture of control and unaffected being as active as expected from the sum of control and unaffected. But all cholinesterase of the unaffected in this experiment and all or nearly all in other experiments appears to be inhibited, the enzyme showing no activity. After that, recovery takes place slowly. Even in the affected ganglia, detoxication seems to occur, as the mixtures in the later stages show some activity.

There is at least one other distinct enzyme, a phenylesterase, present in locust ganglia. (I) is a poor inhibitor of this, and in experiments of the type described its inhibition seems to be more correlated to toxic symptoms than that of cholinesterase. In the absence of information on its natural substrate or on the occurrence of other enzymes it is not possible to speculate on its role in the mode of action of phosphoric insecticides.

Unless synaptic transmission in the locust can be carried on normally by amounts of cholinesterase too small to detect by our method, it appears that a locust may have substantially all its ganglionic cholinesterase inhibited while showing no interference with normal nerve functioning. In that case it is hard to see what the role of this enzyme might be in the locust, or how its inhibition can be the cause of insecticidal action.

O'Brien[5] has shown that cockroaches poisoned by malathion show little *in vivo* reduction of cholinesterase activity, and similar results have been obtained by van Asperen[6] using O,O-dimethyl-O-2,2-dichlorovinyl phosphate on flies. Apparently there are cases when a toxic phosphorus ester produces little *in vivo* cholinesterase inhibition while killing, while others inhibit the enzyme very efficiently without killing.

It is hoped to publish a fuller account of experiments with this and other substances on more than one species in due course.

H. S. Hopf
R. T. Taylor

Imperial Chemical Industries, Ltd.,
Jeallott's Hill Research Station,
Bracknell, Berks.
Aug. 21.

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Pigmentation and Sexuality in Plants

Many angiosperms depend on insects or birds to accomplish pollination or seed dispersal, and the appropriate parts of the plants are brightly coloured, usually with carotenoid or flavonoid pigments. It is generally agreed that these pigments serve a useful purpose in attracting animal visitors, and therefore their presence has selective value; but while this may explain their production and maintenance in some angiosperms, it does not account for their original establishment in the plant kingdom. For carotenoids similar to those commonly found in flowers and fruits occur in all lower groups of plants, and anthocyanins (flavonoids) are found both in mosses[1] and in ferns[2]. Hence there is reason for believing that both types of pigment were produced in plants long before angiosperms had evolved, and have some function or functions unconnected with attracting the attention of animals.

No attempt will be made here to give a comprehensive survey of the alternative functions which have been suggested; this communication is concerned only with the suggestion that there is a connexion between these pigments and the biochemistry of sex. There is considerable evidence for such a connexion with carotenoids, which occur regularly in all groups of plants. The evidence

includes the differential accumulation of carotenoids in the sex organs of fungi[3], and of algae[4], and a correlation between carotenoid concentration and the reproductive cycle in flowering plants[5]. In addition, Moewus[6] claims to have demonstrated an elaborate system of hormones regulating the sexual process in the alga *Chlamydomonas eugametos*, in which carotenoids and their derivatives play an important part, but attempts to reproduce many of Moewus's results have been unsuccessful[7] and his claims should be treated with caution.

A connexion between sexuality and the flavonoid pigments, which occur only sporadically in the plant kingdom, is much less probable. Moewus[6] states that the anthocyanin peonin and the anthoxanthin *iso*rhamnetin are sex-determining hormones in *C. eugametos*; but this is unconfirmed and subject to the same criticism as above. Another piece of evidence comes from the observations of Gascoigne, Ritchie and White[8] on flower pigments in *Casuarina*. These authors identified the anthocyanidins from seven species of the genus, three of which showed no difference between male and female flowers in this respect. In each of the other four species, however, flowers of one sex yielded an anthocyanidin not present in flowers of the other, as shown in Table 1. Of these species, *C. glauca* is always dicœcious, *C. nana* is usually dicœcious, and *C. rigida* and *C. suberosa* may be either monœcious or dicœcious.

Table 1. ANTHOCYANIDINS FROM FLOWERS OF *Casuarina* SPECIES (From Gascoigne, Ritchie and White, ref. 8)

Species	Anthocyanidins represented in: Male flowers	Female flowers
C. glauca Sieb.	cyanidin	cyanidin + delphinidin
C. nana Sieb.	cyanidin	cyanidin + delphinidin
C. rigida Miq.	cyanidin	cyanidin + delphinidin
C. suberosa Ott. et Dietr.	cyanidin + peonidin	cyanidin

There is clearly no consistent difference of pigmentation between the sexes in the genus as a whole, and so it seems unlikely that the anthocyanins play a fundamental part in the biochemistry of sexual differentiation. Nevertheless, the differences observed in individual species seem to be more than coincidental. In particular, *C. glauca*, *C. nana*, and *C. rigida* all show the same difference between flowers of opposite sex, although *C. glauca* is not closely related to the other two species. It is possible that the difference in pigmentation represents a sex-limited character, that is, having only a secondary connexion with sex. For example, flowers of both sexes may have an enzyme which, under suitable conditions, can catalyse the conversion of cyanidin to delphinidin, but which can function only in the biochemical environment of female flowers.

A study of anthocyanin pigments in the flowers of other dicœcious plants has been made on a small scale to see whether the sex difference in *Casuarina* has a parallel elsewhere. Flowers or inflorescences containing anthocyanins were collected from the six species listed in Table 2. Extracts of anthocyanins were made from male and female flowers separately and analysed by paper chromatography, both with and without previous hydrolysis, using techniques and solvents recommended by Bate-Smith[9,10]. For each of the six species, flowers from several male and several female plants in the same population were analysed in this way. In no case was there any evidence of a qualitative difference in anthocyanin pigmentation between flowers of opposite sex. The anthocyanidins were tentatively identified, and are given in Table 2.

Table 2. ANTHOCYANIDINS FROM MALE AND FEMALE FLOWERS OF DICŒCIOUS PLANTS

Species	Anthocyanidins
Melandrium rubrum	cyanidin
Myrica gale	cyanidin + delphinidin
Petasites hybridus	cyanidin
Rumex acetosella	cyanidin
Salix repens	cyanidin
Urtica dioica	pelargonidin

This negative finding strengthens the view that anthocyanins have no direct connexion with sexual differentiation, and that the differences reported for species of *Casuarina* are not representative of some more general phenomenon.

I am grateful to Mr. L. A. S. Johnson, of the National Herbarium of New South Wales, for information about *Casuarina*.

J. N. HARTSHORNE

Department of Botany,
University of Manchester.
Oct. 13.

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Antibody Production by Single Cells

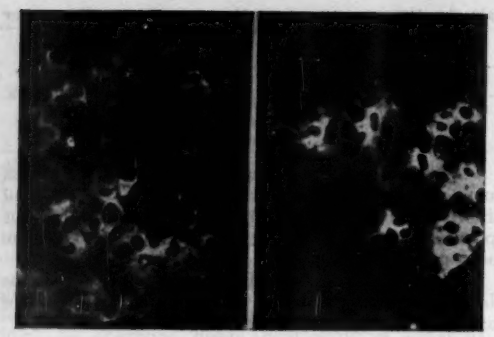
Nossal and Lederberg[1] described an ingenious and elegant method for showing that single cells from rat-lymph nodes, simultaneously stimulated with two antigens, formed antibody to one or other antigen but never to both.

This problem has been explored here by two further techniques which lead to the same general result as that given above, with different antigens and in a different animal species. The two methods employed the fluorescent antibody technique[2].

The first method used frozen sections of lymph nodes of rabbits simultaneously stimulated with two antigens (say *A* and *B*). The mature and immature plasma cells which contain anti-*A* were revealed by the 'sandwich' technique of Coons, Leduc and Connolly[3] using a dilute solution of a mixture of *A* and *B* and anti-*A* labelled with fluorescein. The distribution of fluorescent cells was photographed. The specific fluorescence of these cells was then quenched by exposure of the same microscopical field to long-wave ultra-violet radiation for 20–30 min. After this treatment a photograph confirmed the absence of specific fluorescence. Finally, after removal of the cover glass of the slide preparation, the cells containing anti-*B* were revealed by treatment of the section with fluorescein-labelled anti-*B*.

The second method used antibodies conjugated with red or green fluorochromes: sulphonyl chloride of rhodamine[4] or fluorescein *iso*cyanate. Frozen sections were treated with a dilute mixture of *A* and *B*, and then successively with anti-*A* labelled with fluorescein and anti-*B* labelled with rhodamine.

The first method has been applied to spleen sections from rabbits hyperimmunized by repeated intravenous injections of *Streptococcus pneumoniae* (type III) and crystalline hen's ovalbumin (tissue kindly supplied by Dr. J. H. Humphrey of the National



(*a*) (*b*)

Fig. 1. (*a*) Fluorescence micrograph. Medulla of rabbit spleen. Light areas (yellow-green fluorescence of fluorescein) indicate sites of antibody to capsular polysaccharide of *Str. pneumoniae* type III. Groups of antibody-containing cells (× 360). (*b*) Fluorescence micrograph. Same field as above, after quenching of specific fluorescence and after treatment to reveal distribution of anti-ovalbumin. Another set of cells distinct from those of (*a*) is revealed (× 360)

Institute for Medical Research) and to sections of popliteal lymph nodes of rabbits which were killed 3–6 days after a secondary stimulus of 50 *Lf* of diphtheria toxoid and 1 mgm. of ovalbumin adsorbed to aluminium phosphate, injected into a footpad. The animals had received simultaneous primary stimuli via the footpad with the same two antigens one month previously. The second method used the latter material only.

These treatments produced a heavy proliferation of plasma cells and their precursors in the pulp of the spleen or in the medulla of the popliteal node respectively. Comparison of the successive photographs provided by the first method, employing both combinations of antigens, showed that the two antibodies were located within distinct systems of plasma cell elements (Fig. 1, *a* and *b*). The use of the second method also resulted in two distinct sets of cells containing antibody, one with a yellow-green cellular fluorescence (of nuclei and cytoplasm) denoting anti-ovalbumin and one with the orange-red fluorescence denoting diphtheria antitoxin.

The use of the red and green fluorochromes would reasonably be expected to allow detection of two antibodies within a single cell providing that the amount of one is not grossly disproportionate to the other. The absence of such a result on a limited range of material does not prove that it cannot occur but implies at least that it is unusual.

On the basis of current hypotheses of clonal individuation in antibody formation[6,7] it might be expected that two groups of cells, which are derived by repeated divisions from widely dispersed precursors, would show a characteristic grouping. But although it was possible to discern a tendency for some cells of the same colour to occur in small clumps, marshalled clones of red and green were not apparent. This finding does not necessarily conflict with the hypothesis, providing the cells containing antibody are sufficiently motile in the medulla of spleen and lymph nodes. Evidence exists at least that they are motile[8]. Another type of lymphoid cellular proliferation which follows antigenic stimuli and which satisfies more fully the morphological requisites of clonal division is seen in the germinal centres of the lymphoid nodules. In certain circumstances these cells can be shown to contain antibody[8,9], and in my experience with animals producing both diphtheria antitoxin and anti-ovalbumin the cells of such a centre are nearly all of one kind (that is, either all green or all red by the above technique) and, thus far, appear to conform to the requirements of a clonal hypothesis.

R. G. White

Department of Bacteriology,
London Hospital, E.1.
Aug. 21.

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Effect of Calcium Ions on the Binding of Chromium-51 to Erythrocytes *in vitro*

Since Gray and Sterling[1] introduced the method of labelling erythrocytes with chromium-51 *in vitro*, numerous papers have appeared showing the usefulness of this method for determining the total red corpuscle mass and the life-span of the individual's own erythrocytes[2].

In spite of the widespread use of chromium-51 as a labelling agent for the erythrocytes, relatively little is known about the basic mechanism of chromate binding to the erythrocytes. It has been shown repeatedly that the percentage uptake of chromium-51 by red corpuscles is higher using isotonic sodium citrate (ACD) solution as an anticoagulant than when heparin is used[3].

We wish to report that the presence of calcium ions in the incubation medium diminishes the uptake of chromium-51, added as sodium chromate, by erythrocytes and hæmoglobin *in vitro*.

Fresh human blood was drawn into different anticoagulants. The preparation of globin and hæmoglobin solutions will be described elsewhere by one of us (B. Z.). Labelled sodium chromate ($Na_2{}^{51}CrO_4$) with a specific activity of 5 μc./μgm. of metallic chromium was employed. 0·3 μc. of chromium-51 was added to 5 ml. of whole blood. The blood was incubated at 20° C. for 2 hr. After centrifuging, the red corpuscles were washed four times with physiological saline and, after hæmolysis, their radioactivity was compared to that of a standard sample.

Using heparin as an anticoagulant, the uptake of chromium-51 by the erythrocytes is reduced to two-thirds of the uptake in isotonic sodium citrate or oxalate solutions.

Table 1 shows that the calcium ions reduce the amount of chromium-51 taken up by erythrocytes suspended in saline or in recalcified sodium citrate plasma from about 90 per cent to about 60 per cent of the added chromate. The binding of chromium-51 to human globin or hæmoglobin *in vitro* is similarly decreased in the presence of calcium ions (unpublished work by B. Z.). This fact suggests that the effect of calcium ions on the uptake of chromate by red corpuscles is probably not due to a change in membrane permeability of the erythrocytes. Further

Table 1. The Effect of Calcium Ions on the Uptake of Chromium-51 by Human Erythrocytes *in vitro*

Incubation medium	Percentage of uptake
ACD-solution* whole blood = 1/4	90
ACD-solution* whole blood = 1/4 + Heparin	89
ACD-solution* whole blood = 1/4 + Heparin + 2 mgm. Ca^{2+}/ml.	58
Saline Packed RBC = 2/1	91
Saline Packed RBC = 2/1 + 0·1 mgm. Ca^{2+}/ml.	63

* Natr. citr. tribas., 1·32; acid. citr., 0·48; glycos., 1·47; aqua dest., ad 100 ml.

studies on the mechanism of the inhibition of chromate-binding to erythrocytes or hæmoglobin by calcium ions, and on the influence of calcium ions on the elution of chromium-51 from the erythrocytes, are in progress in this laboratory.

Our grateful thanks are due to Prof. G. de Hevesy for stimulating interest taken in this investigation; to Statens Naturvetenskapliga Forskningsråd; and to Riksföreningen för Kräftsjukdomarnas Bekämpande, Cancernämnden, for financial support.

G. von Ehrenstein
B. Zacharias
Institute of Organic Chemistry and Biochemistry,
University of Stockholm. Aug. 10.

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Volume and Acidity of Urine of Sheep fed Hay Rich in Silica and Effect of Dietary Salt Additions

The results reported in this communication were obtained as part of a study related to a condition of silica urolithiasis which had been observed in steers on the Western Ranges of Canada and the United States. Experiments in this laboratory have shown that sheep fed a hay from Western Canada containing 8·28 per cent silica (expressed on air-dry basis) excreted urine with a *p*H of approximately 5·5. Sheep in the control group that were fed a hay from Eastern Canada containing 0·78 per cent silica excreted urine with a *p*H of approximately 8·2. Consumption of water and excretion of urine by sheep fed the high-silica hay were about one-half that of the sheep in the control group.

The polymerization of silicic acid in aqueous systems is dependent on concentration and *p*H. Rate of polymerization is stated to be inversely proportional to the square of the silica concentration[3] and most rapid at *p*H 5·5–6 (ref. 3), 5·8 (ref. 4), 5–7 (ref. 5). It is therefore possible that the effects on volume and *p*H of urine that resulted from the feeding of Western grass hay may play a part in the formation of silica calculi.

The proximate composition and cation content of the two hays is given in Tables 1 and 2. The Western hay was mainly *Stipa*, probably *Stipa comata*, whereas that from Eastern Canada consisted of second cut red clover (*Trifolium pratense*). In the experiment reported here two groups of three sheep were used. One group was fed the Eastern and the other the Western hay, with salts added in order to render the cation content of the two diets approximately equal. Each sheep on Western hay received daily the following additions based on an average daily hay consumption of 1,000 gm.: sodium hydrogen phosphate, 2·4 gm.; magnesium carbonate, 3·3 gm.; magnesium sulphate, 4·7 gm.; calcium carbonate, 15·0 gm.; potassium bicarbonate, 15·6 gm.; potassium chloride, 6·5 gm. Sheep fed the Eastern hay were given a daily addition of 112·5 gm. silica in the form of a commercial silica gel based on an average daily consumption of hay of 1,500 gm. Four samples of urine were collected daily over a 4-week period and the *p*H values determined on the fresh urine. 24-hr. urine volumes were determined three times a week.

Table 1. Proximate Percentage Analyses of Eastern and Western Hays

	Protein N × 6·25	Fat	Crude fibre	Ash	N-free extract
Eastern hay	11·74	1·46	31·32	6·72	48·76
Western hay	5·87	1·89	32·63	13·06	46·55

Table 2. Mineral Analyses of Eastern and Western Hays

	Na	K	Ca	Mg	P	SiO_2
Eastern hay	0·06	1·35	0·92	0·27	0·15	0·78
Western hay	0·02	0·44	0·32	0·08	0·12	8·28

Addition of silica to the diet had very little effect on either the volume or the *p*H of the urine. On the other hand, addition of salts to the diet of sheep fed the Western hay resulted in a urine volume comparable to that of the control group. In addition there was some elevation in urine *p*H but this was subject to considerable fluctuation. In order to overcome this fluctuation in *p*H, equivalent amounts of magnesium and potassium as magnesium carbonate and potassium bicarbonate were used to replace the magnesium sulphate and potassium chloride. This resulted in *p*H values of approximately 8·0. No ill effects attributable to the administration of salt were observed during the experiment.

Our studies on urolithiasis so far have suggested that low *p*H and low excretion of urine may be important factors contributing to the formation of silica calculi. If this is correct, proper additions of salts to the diet may contribute to the reduction of silica urolithiasis.

A more detailed account of these experiments will be published in the near future.

S. A. Forman
F. Sauer
D. H. Laughland
W. M. Davidson
Chemistry Division,
Science Service,
Canada Department of Agriculture,
Ottawa.
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Vitamin B_{12} in Marine Fish

In the course of a comparative investigation of the vitamin contents of different organs from fish[1], a rather interesting relative distribution, and in some cases unusually high concentrations, of vitamin B_{12} were observed. As the importance of vitamin B_{12} in marine ecology has been emphasized in recent reports[2–6], a brief account of the main findings is given in this communication.

Vitamin B_{12} was determined by microbiological assays with *Lactobacillus leichmannii*. To ensure that the growth-promoting activity measured was derived from vitamin B_{12}, checks were carried out by paper chromatography.

Although most organs have been investigated the complete results cannot be reported here. In Table 1 are shown the results of analyses of: muscle, kidney, liver and heart from some species. The most striking results are the frequent high values for vitamin B_{12} in the heart: single values up to 5 μgm. vitamin B_{12} per gm. fresh weight (20·8 μgm. per gm. dry weight) were found in hearts from the pollack (*Gadus pollachius*). So far as we know such high concentrations are very unusual in any natural source[6]. Another interesting result was the relation between the vitamin B_{12} content of liver and heart. In some cases the heart showed up to 150 times the value for the liver in the same fish. Normally, kidney and liver are recognized as the organs richest in vitamin B_{12}[7], but the present findings show that in fish the heart often contains the highest concentration. Tarr *et al.*[8] found in the kidney of the sockeye-salmon 18 μgm. vitamin B_{12} per gm. solids. Several other organs from this fish were also investigated, but unfortunately not the heart. In none of the species I investigated were such values for kidneys encountered.

Table 1. The Vitamin B_{12} Content of some Organs from Fishes

Species	μgm. vitamin B_{12} per gm. fresh weight			
	Muscle	Kidneys	Liver	Heart
Cod (*Gadus morrhua*)	0·005	0·045	0·045	1·85
Coalfish (*Gadus virens*)	0·035	0·070	0·14	0·50
Pollack (*Gadus pollachius*)	0·018	0·16	0·33	4·25
Haddock (*Gadus aeglefinus*)	0·018	0·32	0·067	2·58
Ling (*Molva molva*)	0·006	0·20	0·11	0·26
Tunny (*Thunnus thynnus*)	0·037	0·35	3·53	0·85
Plaice (*Pleuronectes platessa*)	0·022	0·37	5·00	0·81

So far the general picture seems to be that undernourished fish with very fat livers show low values for vitamin B_{12} in the livers and often very high values for the heart. Fat fish with 'normal' livers usually show the highest values for this organ, although high concentrations are also encountered in the hearts.

The results from the plaice (*Pleuronectes platessa*) deserve some comments. This fish lives in shallow waters where both the sea and most of its food may be expected to contain relatively high concentrations of vitamin B_{12}. It is therefore interesting to note the relatively high average value for the liver from this fish. Actually, in one of the samples from plaice the liver contained 8 μgm. vitamin B_{12} per gm. fresh weight (50 μgm. per gm. fat-free dry weight).

The results emphasize the position of the fish in the turnover of vitamin B_{12} in marine life. A detailed account of this work will be published elsewhere.

Olaf R. Brækkan

Governmental Vitamin Laboratory,
Norwegian Fisheries Research Institute,
Bergen. Aug. 25.

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Deoxyribonuclease Activity and Deoxyribonucleic Acid Synthesis in Normal, Regenerating, Precancerous and Cancerous Rat Liver

Increase in the rate of deoxyribonucleic acid synthesis is a biochemical characteristic of hyperplastic growth. Whereas the rate of growth under normal conditions is under rigorous control, malignant growth may be characterized by the impairment of this kind of control. Since deoxyribonucleic acid synthesis is necessary for cell division, it is possible that this control may be exercised by the regulation of deoxyribonucleic acid metabolism. The purpose of this communication is to direct attention to a number of observations which, taken together, seem to indicate that deoxyribonuclease may be involved in such regulation.

In previous experiments[1,2] a close correlation between the activity of a deoxyribonuclease with *p*H optimum close to 5 and growth-rate or rate of synthesis of deoxyribonucleic acid has been demonstrated in normal tissues; increase in growth-rate was in all cases studied associated with increase in the level of deoxyribonuclease activity per cell. In contrast to this pattern in normal tissues, a lack of correlation between growth-rate and deoxyribonuclease activity was found in a series of malignant human and animal tissues[3]. The deoxyribonuclease activities of the tumours were approximately equal to, or lower than, those found in the tissues of origin.

In the search for an explanation of these apparent differences between normal and malignant growth, a systematic study has been made of the deoxyribonuclease activity in rat liver in various types of normal and malignant growth. Such a study makes possible a comparison of these various conditions in a single organ. Male Sprague–Dawley rats, weighing 250–300 gm., were used. The enzymic activities were determined in normal adult liver, in regenerating liver after partial hepatectomy, and in precancerous and cancerous livers, where the tumour was induced by feeding a rice diet containing 0·06 per cent *p*-dimethylaminoazobenzene[4] and supplemented with carrots. After three months, casein was added to the diet. The deoxyribonucleic acid phosphorus content and deoxyribonuclease activities were determined as described previously[5].

Table 1 is a summary of some of the results. Compensatory hyperplasia after partial hepatectomy is accompanied by an increase in deoxyribonuclease activity; the increase is very rapid and is observed

Table 1. DEOXYRIBONUCLEASE ACTIVITY AND DEOXYRIBONUCLEIC ACID PHOSPHORUS CONTENT IN NORMAL, REGENERATING, PRECANCEROUS AND CANCEROUS RAT LIVER

Experimental procedure	Characterization of tissue	No. of animals	Wet weight of livers (gm.)	μgm. DNAP* per gm. dry weight	mgm. DNAP* per total organ	DNaset per μgm. DNAP*	DNaset per total ogan
Normal controls		6	11·83	710	2·35	9·4	22,000
Sham operation	24 hr. after op.	2	—	705	—	10·5	—
Partial hepatectomy	12 hr. after op.	3	4·29	642	0·77	12·3	9,470
	24 ,, ,, ,,	15	4·83	550	0·77	16·4	12,600
	36 ,, ,, ,,	8	6·44	580	1·09	15·0	19,400
	41 ,, ,, ,,	4	6·67	670	1·16	18·0	20,880
	48 ,, ,, ,,	4	7·87	740	1·70	17·1	29,000
	72 ,, ,, ,,	8	8·65	750	1·98	16·1	31,880
p-Dimethylaminoazobenzene fed	4 days	4	11·60	692	2·34	10·3	24,310
	8 ,,	4	11·36	835	2·83	9·6	27,460
	14 ,,	4	12·24	826	3·04	15·2	46,200
	60 ,,	4	11·96	1,210	4·45	15·3	68,540
	90 ,,	3	12·99	950	3·33	12·9	47,700
	150 ,, ‡	1	—	1,040	—	11·7	—
	150 ,, §	1	—	3,140	—	5·7	—

* DNAP, deoxyribonucleic acid phosphorus.
† DNase (deoxyribonuclease) activities were determined by incubating tissue homogenates with calf thymus deoxyribonucleic acid at pH 5·25, adding trichloracetic acid – lanthanum acetate and centrifuging. The increase in deoxypentose in the supernatant was determined colorimetrically (ref. 5) and from this the amount of deoxyribonucleic acid phosphorus was calculated. The deoxyribonuclease activities are expressed as μgm. deoxyribonucleic acid phosphorus liberated per hr. per μgm. tissue deoxyribonucleic acid phosphorus or per total organ.
‡ Diffuse tumour infiltration.
§ Excised solid hepatoma.

as early as 12 hr. after operation. A high level of deoxyribonuclease is also found in rats on the *p*-dimethylaminoazobenzene diet. It is observed after 14 days, and approximately the same level is found at 60 days. After 90 days the value gradually decreases. The lowest values are found in the hepatoma. The deoxyribonuclease activity of this tissue is considerably lower than that of normal adult liver.

The growth response to partial hepatectomy in terms of deoxyribonuclease increase is very rapid. At 36 hr. after the operation, the remaining fragment of liver has a total deoxyribonuclease activity approximately equal to that of the intact organ, whereas during the same time interval only a fraction of new deoxyribonucleic acid has been synthesized (Table 1). The figures indicate that the peak-rate of deoxyribonucleic acid synthesis occurs somewhere between 39 and 44 hr. after partial hepatectomy. The prolonged stimulation of growth exerted by *p*-dimethylaminoazobenzene is associated with higher levels of deoxyribonuclease during the early stages of the carcinogenic process. The induced hepatoma, however, appears to have lost the capacity to respond to the continuous growth stimulation with an increase in deoxyribonuclease activity.

These findings seem to be in harmony with the protein deletion hypothesis put forward by Miller and Miller[6]. During precancerous stages, there is an accumulation of protein-bound derivatives of the azo dye in the rat liver. This seems to cause hyperplasia, which is accompanied by increase in cellular deoxyribonuclease activity. This increase appears to be a general reaction of the normal cell to a growth stimulus[1,2]. Gradually, however, a new type of cell, the cancer cell, appears, lacking, *inter alia*, the protein fractions which in the normal rat liver cell are bound to derivatives of the dye[6]. It is conceivable that some of these protein fractions might be concerned with deoxyribonuclease synthesis.

In summary, it can be said that in the rat liver during non-malignant growth increased rate of deoxyribonucleic acid synthesis is accompanied by increased deoxyribonuclease activity. The malignant cell is characterized by considerably increased rate of deoxyribonucleic acid synthesis[7] and subnormal deoxyribonuclease activity. During the carcinogenic process induced by *p*-dimethylaminoazobenzene, the early stages are associated with increased deoxyribonuclease activity, which decreases during the later phases of this process.

A detailed report on these findings and parallel histological changes will be published elsewhere.

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SAM BRODY*
Laboratories of the Sloan-Kettering Division,
Cornell University Medical College,
New York 21, N.Y. Aug. 15.

* Permanent address: Department of Women's Diseases, Karolinska Sjukhuset, Stockholm 60, Sweden.

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Importance of Zinc for the Growth of Surface-Culture of *Mycobacterium tuberculosis* var. *bovis* and Large-scale Production of Tuberculin Purified Protein Derivative

DURING the past eight years of large-scale cultivation of *Myc. tuberculosis* var. *bovis* '*AN5*' on the Dorset–Henley synthetic liquid medium[1,2] for the production of tuberculin purified protein derivative, from time to time and especially during the past two years we have met serious difficulties due to premature sinking of the pellicles, about 3–6 weeks after inoculation (the normal time before harvesting being 8 weeks). Growth came to a standstill and losses in tuberculin production were substantial.

We checked several crucial points in the procedure, including the possibility that toxic products, for example peroxide, developed during autoclaving. We also introduced some improvements. By placing the penicillin flasks, in which the pellicles are grown, on a slant instead of horizontally, condensed moisture was prevented from dripping down. In this way the piercing of holes in the pellicles by water drops was

avoided. By introducing in the inoculation scheme more natural media, such as Stonebrink's egg–pyruvic acid medium and Sauton's potato medium, we got better seed material. Nevertheless, the main cause of sinking still remained undetected and we turned our attention to trace elements, which had previously been neglected in checking the medium constituents.

L. A. Baisden[3] recommended the addition of many elements to the Dorset–Henley medium, which is composed of: L-asparagine, dipotassium hydrogen phosphate, trisodium citrate, magnesium sulphate, ferricitrate, glucose and glycerine. This was mainly because many brands of asparagine do not contain the impurities necessary for good growth of *Mycobacterium* cultures. Drea and Andrejev[4] pointed out some essential elements but they considered several others, including zinc and manganese, unessential.

A striking result of the investigations of Williston *et al.*[5] on the reasons for the premature sinking of some of their BCG cultures on Sauton media was the detection of the favourable effects of traces of zinc, present in some of their glycerine batches due to corrosion of galvanized containers. Similar results were obtained by Loginova[7].

Williston *et al.*[5] recommended the addition of both zinc and manganese, even if traces of these elements were present in the other constituents of the medium. We therefore investigated the effects of zinc on our bovine *AN5* strain on the Dorset–Henley medium.

Zinc estimations, carried out since April 1958 on our glycerine batches and on complete culture medium revealed that less than 2 μgm./ml. was present. Manganese, often encountered in natural asparagine and probably in ferricitrate, was present, at concentrations of about 1–3 μgm./ml. medium.

We therefore added to our media: 10 μgm. zinc/ml. (60 flasks); 10 μgm. zinc + 2·5 μgm. manganese/ml. (5 flasks); 10 μgm. zinc + 2·5 μgm. manganese + 0·35 μgm. cobalt/ml. (5 flasks). The elements were added as A.R. sulphate, chloride and chloride respectively. Five flasks with non-enriched media served as controls.

We used cobalt (Williston *et al.*[5] were doubtful about its effect on growth) to neutralize peroxide which might be formed by autoclaving Mn++ and citrate[6]. Sinking occurred in the controls after about 3 weeks, while the other inoculates grew satisfactorily. The pellicles grown on the three kinds of enriched media appeared normal at the time of harvesting, and were indistinguishable by eye from each other. Similarly, the addition of more zinc (20 μgm. zinc + 2 μgm. manganese + 0·35 μgm. cobalt) gave excellent results.

It must be pointed out that pellicles of the human strains *DT*, *C* and *PN* were slightly less apt to sink than those of the bovine strain. Human strain pellicles did not sink on the zinc-deficient media on which bovine pellicles did, though the growth was not so good as on media to which zinc had been added.

The yields of tuberculin from all the enriched batches were about 1·5–2 times those from sinking cultures, and equal to, or perhaps slightly better than, from our former successful cultures in which trace-elements were not investigated.

The colour of the protein precipitate from media enriched with zinc is strikingly whiter than that from sinking cultures. This led us to suppose that possibly the proportion of the almost white '*A* + *B*' proteins, known for their greater specificity in the intradermal test[8], might be higher in the former case.

Tested on guinea pigs sensitized with mammalian tuberculosis, the potency of the 'zinc-added' tuberculin (15 *TU* per injection) proved to be significantly higher than that of tuberculin from sinking cultures. The average swelling diameters were respectively 13·5 and 11·1 mm. On the other hand, the reactions provoked by 1,500 *TU* on avian-sensitized guinea pigs were similar for both products. Higher specificity is thus indicated as well.

Confirmation of this was provided by chromatography[9]: the percentage of '*A* + *B*' protein in 'zinc-added' tuberculoprotein was about 2–3 times that in tuberculoprotein from sinking cultures.

T. Dekker
H. Huitema

Rijksseruminrichting,
Rotterdam.
Sept. 12.

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Immunology and Chromatography in Taxonomic Studies on Gallinaceous Birds

I have recently described a correlation between antigenic properties and hæmoglobin composition of the blood of some passerine birds[1]. The relationships of red-cell antigens and of hæmoglobins suggested some possible phylogenetic affinities among these birds, since these characters are gene-determined. There was very little intraspecific variability.

An immunological analysis of red-cell antigens and a chromatographic analysis of pectoral muscle of three species of gallinaceous birds have been made. The three species, *Numida meleagris*, *Gallus gallus* and *Meleagris gallopavo*, belong, according to Wetmore's classification[2], to three different families of the order Galliformes, sub-order Galli, superfamily Phasianoidea.

The genetic properties of red-cell antigens and the inferences that can be drawn from immunological relationships on phylogeny and systematics have been largely discussed[3]. Also the application of paper partition chromatography has proved useful for understanding phylogenetic relationships. Buzzati-Traverso and Rechnitzer[4], Buzzati-Traverso[5], Micks[6] and Fox[7] have shown that chromatographic patterns of different species show constant differences, independently of environmental conditions, and that their similarities run parallel to their phylogenetic affinities.

The anti-erythrocytes sera of the three species of birds have been obtained from rabbits; the specific antigens have been separated from the common ones by absorption, and titrations have been made in serial dilutions at 37° C. The titres are given in Table 1. Every species possesses: (1) specific antigens; (2) antigens common to the other two species; (3) antigens common only to one of the other two. There is greater immunological affinity, that is, more common antigens, between *Meleagris gallopavo* and

Table 1

Antiserum	Absorbing cells	Test cells		
		Gallus	*Numida*	*Meleagris*
Gallus	—	1/1,280	1/80	1/40
	Numida	1/640	—	1/20
	Meleagris	1/640	1/20	—
Numida	—	1/40	1/5,120	1/320
	Gallus	—	1/640	1/160
	Meleagris	1/20	1/40	—
Meleagris	—	1/80	1/1,280	1/1,280
	Gallus	—	1/640	1/320
	Numida	1/10	—	1/320

Numida meleagris than between these two species and *Gallus gallus*.

For ascending paper partition chromatography the following technique has been used. Pectoral muscle is homogenized in a tissue grinder with distilled water (1 muscle : 2 distilled water); then, after centrifugation, the supernatant is deproteinized by 20 per cent trichloracetic acid, and the excess of the latter is removed by ether. The liquid is concentrated (1/3) by evaporation at 2° C. Whatman No. 1 filter paper is used. The solvent consists of 1 part of 1 per cent ammonia and 2 parts of *n*-propanol. The chromatograms are sprayed with a 0·2 per cent solution of ninhydrin in 95° ethanol.

Chromatographic patterns of pectoral muscle of several individuals of the same species were identical.

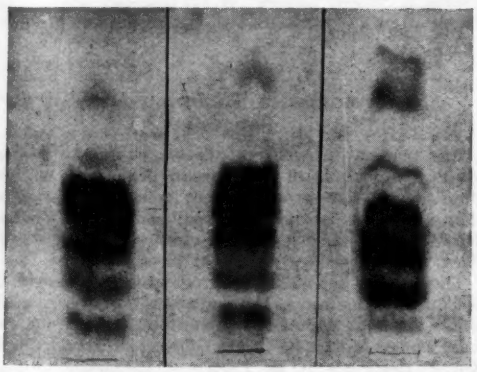

Fig. 1

As can be seen in Fig. 1, there is greater similarity between the chromatograms of *Numida meleagris* and *Meleagris gallopavo* than between these two species and *Gallus gallus*. Consequently, this chromatographic similarity confirms the closer immunological affinity between *Numida* and *Meleagris*.

DANILO MAINARDI
Istituto di Zoologia e Anatomia comparata,
Università di Parma,
Italy.
Sept. 9.

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The Heterozygous Carrier in Galactosæmia

GALACTOSÆMIA is a hereditary disorder of carbohydrate metabolism characterized by vomiting, diarrhœa, jaundice, poor weight gain and malnutrition during early infancy. Mental retardation, cataracts and cirrhosis of the liver are common complications. The diagnosis can be made by a markedly elevated galactose tolerance test, and identification of galactose in the urine. In 1956, Schwarz, Goldberg, Komrower and Holzel[1] showed that galactose-1-phosphate accumulates in the erythrocytes of galactosæmic children if they receive galactose or milk. This indicated that galactokinase must be present in such individuals. In the same year, Isselbacher, Anderson, Kurahashi and Kalckar[2] demonstrated a deficiency of galactose-1-phosphate-uridyl transferase in the erythrocytes of these children. This indicated that the site of the metabolic block in this disease was at the step of:

$$\text{Galactose-1-PO}_4 + \text{UDP glucose} \rightleftharpoons \text{UDP galactose} + \text{glucose-1-PO}_4$$

The frequent occurrence of this condition in siblings and among the offspring of consanguineous matings together with its equal distribution in both sexes suggest that galactosæmia is probably transmitted by a single autosomal recessive gene. In this situation, one would expect the disease to occur only in persons who receive two of the abnormal genes, one from each parent. If one individual is heterozygous for the condition, he will usually be free of clinical symptoms. Careful biochemical studies, however, might reveal minor departures from the norm[3]. Holzel and Komrower[4] undertook galactose-tolerance tests among parents, siblings, and near relatives of six families with known cases of galactosæmia. They found the response to be abnormal in a number of the relatives tested, but this was not a consistent finding among all the individuals who should be heterozygous. Furthermore, in the majority of cases, usually only one of the parents showed a lowering of the galactose-tolerance test.

The purpose of the present communication is to report on the measurement of galactose-1-phosphate-uridyl transferase activity in five galactosæmic families. In each instance, the diagnosis of galactosæmia was established by identifying the presence of galactose in the urine through paper chromatographic separation or by the osazone and mucic acid test or both. Galactose-1-phosphate-uridyl transferase activity was assayed by the method of Anderson, Kalckar, Kurahashi and Isselbacher[5], as follows. Red blood cells of fasting venous blood were washed twice with a double volume (twice the volume of the packed cells) of 0·9 per cent sodium chloride and hæmolysed by the addition of an equal volume of cold distilled water. Hæmolysate was then incubated with uridine diphosphoglucose (UDPG), galactose-1-phosphate, and *tris* glycine buffer for 30 min. at 37° C. For each sample, a control was run where no galactose-1-phosphate was added to the substrate. After incubation, diphosphoglucose was determined in heat-inactivated hæmolysates by means of diphosphoglucose dehydrogenase. The difference between the measurements of diphosphoglucose in the sample and control represents the amount of it consumed due to the activity of galactose-1-phosphate-uridyl transferase. Uridine diphosphoglucose pyrophosphorylase activity was

Table 1. Galactose-1-phosphate-uridyl Transferase Activity (expressed as Units/gm. Hæmoglobin) in Six Galactosæmic Families

Family	Parents		Children	
	Father	Mother	Affected	Unaffected
(*a*) Families where parents are heterozygotes				
1	3·2	2·6	0·31 ; 0	—
2	3·8	5·4	0	3·2
3	5·5	4·5	0 ; 1·1	—
4	2·5	1·9	3·6*	—
5	1·8	1·7	0·6 ; 1·0	1·8 ; 2·5
(*b*) Family where offspring are heterozygotes				
	Father		Offspring	
6	0·9		1·7 ; 2·1 ; 4·1	

* Sample taken from 3-kgm. infant after receiving 195 ml. of whole blood.

Table 2. Summary of Galactose-1-phosphate-uridyl Transferase Activities of Normals, Heterozygotes and Affected

	Galactose-1-phosphate-uridyl transferase activity (unit/gm. hæmoglobin)		
	Normal controls	Heterozygotes	Affected
No. of subjects	11	12	8
Mean	4·5	3·3	0·5
S.D.	± 1·5	± 1·2	± 0·12
Range	2·8–7·0	1·7–5·5	0–1·07

also determined to assure that the blood sample and the hæmolysate were properly handled.

Results for eleven normal controls, twelve heterozygotes (nine were parents, two were offspring, and one was both a parent and an offspring of patients with galactosæmia) and nine galactosæmics are tabulated in Table 1 and summarized in Table 2. It would appear that about half the levels of galactose-1-phosphate-uridyl transferase among the heterozygotes lie below the range of the normal controls, and the difference between the means is significant at the 0·05 level.

All the blood samples were taken in a fasting state. A dose of 40 gm. of D-galactose was given by mouth to four of the heterozygotes and 1·25 gm./kgm. body-weight to two of the affected children. In Table 3 are listed the galactose and galactose-1-phosphate-uridyl transferase levels in whole blood and the erythrocytes respectively before, 1 hr. and 2 hr. after this load. There appears to be a decrease in the galactose-1-phosphate-uridyl transferase activity following the load in both of the affected children and in two of the four heterozygotes. The possible significance of these findings is being further evaluated.

While the results in a single individual must be interpreted with caution, the lower values of galactose-1-phosphate-uridyl transferase found in a group of heterozygotes offer confirmation for the view that the lack of this enzyme is the primary biochemical lesion in galactosæmia. Furthermore, the decrease of this enzyme in the heterozygote with one abnormal gene and its virtual absence in the homozygote with two abnormal genes extend the possibility of detecting heterozygous carriers biochemically, as in the case of abnormal hæmoglobins[6], phenylketonuria[7] and glycogen storage disease of the liver (Hsia, D. Y. Y., and Gawronska, E., unpublished work).

Table 3. Blood Galactose Level and Galactose-1-phosphate-uridyl Transferase Activity following the Administration of 40 gm. of D-Galactose to Four Heterozygotes, and 1·25 gm./kgm. Body-weight to Two Galactosæmic Children

Time (hr.)	Galactose (mgm. per cent)			Galactose-1-phosphate-uridyl transferase (units/gm./kgm.)		
	0	1	2	0	1	2
Affected	7	86	54	0·6	0·5	0·3
Affected	10	45	10	1·0	0·8	0·5
Heterozygote	7	31	10	1·8	1·0	0·9
Heterozygote	8	28	6	1·7	1·8	1·7
Heterozygote	4	53	8	3·2	2·5	1·8
Heterozygote	5	43	40	2·5	2·9	2·2

We wish to thank Drs. Aaron Grossman, Frederick Phillips and Alvah Newcomb for referring the cases to us. These investigations were aided by grants from the Schweppes Foundation, the Chicago Community Trust, and the Otto S. A. Sprague Memorial Institute.

David Yi-Yung Hsia
Irene Huang
Shirley G. Driscoll

Genetic Clinic,
Children's Memorial Hospital,
and Department of Pediatrics,
Northwestern University Medical School,
Chicago, Illinois.

Aug. 10.

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Fomes noxius, a Thiamine-deficient Fungus

The tropical brown root disease, caused by *Fomes noxius* Corner[1], is of widespread occurrence and is found on the roots of a great number of tropical plants such as *Artocarpus*, *Cinchona*, *Cacao*, *Coffea*, *Grevillea*, *Erythrina*, *Eriodendron*, *Elaeis*, *Hevea*, *Thea*, *Theobroma* and of forest trees.

The correct scientific designation of the fungus is not quite clear, and various authors have recorded it under different names : for example, Petch[2] refers to it as *Fomes lamaensis* (Murr.) Sacc. ex Trott., while Roger[3] describes it as *Phellinus lamaensis* (Murr.) Sacc. ex Trott. In this communication Corner's designation is followed.

The distinguishing characteristic of the brown root disease is the fine brown fungus mycelium which covers the roots of affected plants like a sheath ; soil particles and small stones adhere to this brown mycelium cover. The fungus later forms a thick brown or blackish felted crust on the affected root. The outer layer of the crust is brittle and blackish in appearance but the mycelium of the inner layer remains mostly brown. Under this crust the diseased bark disintegrates and the wood is penetrated by a network of branching brownish-black lines or by bands of the mycelium.

So far as can be ascertained from available literature[4], *Fomes noxius* has not yet been grown or investigated in pure culture.

As *Fomes noxius* belongs to the group of the Hymenomycetes which is known to be partially or totally deficient in thiamine (aneurin, vitamin B_1), the requirements of this fungus in this particular respect have been investigated.

Attempts to grow *Fomes noxius* in purely artificial media, as those of Czapek, Fries, Richard or Knop, were unsuccessful. However, as soon as organic materials, such as malt extract, yeast extract, decoction of wood of *Hevea brasiliensis* or of fresh *Hevea* leaves were added, luxuriant growth of the fungus was observed. The fungus also grows well on sterilized pieces of fresh rubber wood and of the roots of rubber, tea or cocoa plants.

Our experiments were carried out in 500-ml. Jena Erlenmeyer flasks, each series consisting of ten flasks. All experiments were replicated three times, and the chemicals used were of analytical grade.

In order to obtain a uniform inoculum for these experiments, the fungus was pre-cultivated for 42 days on sterilized pieces of fresh rubber wood. The mycelium suspension was prepared by adding 100 ml. of sterile distilled water to each flask followed by vigorous shaking. The Erlenmeyer flasks containing the culture media were then inoculated by the wet method, each flask with 0·5 ml. of the mycelium suspension, and the cultures then incubated for 28 days at 27° C.

Knop solution containing 10 gm./l. of vitamin-free glucose was used as basic medium for these experiments.

Table 1. *p*H AND MYCELIUM DRY WEIGHTS IN MGM. OF *Fomes noxius* ON KNOP-GLUCOSE MEDIUM WITH AND WITHOUT ASPARAGINE, THIAMINE, THIAZOLE OR PYRIMIDINE AFTER 28 DAYS AT 27° C.

Culture medium, Knop +	*p*H of culture medium at beginning	at end	Mycelium per flask (dry weight in mgm.)
10 gm./l. glucose	5·0	4·7	1·8
10 gm./l. glucose 1 gm./l. asparagine	5·0	3·5	3·3
10 gm./l. glucose 0·5 mgm./l. pyrimidine	5·2	5·1	2·4
10 gm./l. glucose 0·5 mgm./l. thiazole	5·2	4·6	3·0
10 gm./l. glucose 1 gm./l. asparagine 0·5 mgm./l. pyrimidine	5·2	3·3	10·4
10 gm./l. glucose 1 gm./l. asparagine 0·5 mgm. /l. thiazole	5·3	3·8	12·2
10 gm./l. glucose 0·5 mgm./l. pyrimidine 0·5 mgm./l. thiazole	5·0	4·8	2·7
10 gm./l. glucose 1 gm./l. asparagine 0·5 mgm./l. pyrimidine 0·5 mgm./l. thiazole	5·3	4·8	288·6
10 gm./ml. glucose 1 mgm./l. thiamine	4·9	4·8	3·8
10 gm./l. glucose 1 gm./l. asparagine 1 mgm./l. thiamine	5·2	5·1	291·2
10 gm./l. glucose 10 gm./l. malt extract	5·2	3·8	337·0
10 gm./l. glucose 10 gm./l. yeast extract	5·4	8·2	346·2

It will be seen from the results of this experiment that *Fomes noxius* is unable to synthesize either the whole thiamine molecule or its two constituent parts, pyrimidine and thiazole, but is able to combine pyrimidine and thiazole into thiamine. It thus differs from *Fomes lignosus*[5], which has been shown to be able to synthesize at least one part of the thiamine molecule, namely, thiazole. *Fomes noxius* is further unable to grow on pure Knop solution with glucose and thiamine, or with glucose and pyrimidine plus thiazole, if asparagine is absent. It seems, therefore, that *Fomes noxius* is unable to make use of nitrogen supplied in the form of nitrate.

Work in progress should show whether *Fomes noxius* is able to replace asparagine as a source of nitrogen by other forms of organic nitrogen, or by ammonium.

A. RIGGENBACH

Plant Pathology Department,
Rubber Research Institute of Ceylon,
Dartonfield, Agalawatta,
Ceylon. Aug. 12.

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Confusion between *Gromia oviformis* and *Allogromia ovoidea*

Gromia oviformis Dujardin, 1835, and *Allogromia ovoidea* Rhumbler, 1903, are marine rhizopods with which the general zoologist is usually acquainted. The former is well known because of its abundance in the inter-tidal zones around the rocky parts of the British coasts, and reference has been made to it in some text-books of invertebrate zoology and protozoology. *Allogromia ovoidea*, although less well known as a living animal, has been prominently figured on many occasions in standard zoological text-books. During the past fifty years a great deal of confusion has arisen concerning these two protozoans, as a result of which incorrect names are now given in several text-books and standard works of reference.

The confusion which exists is shown in the following names given by authors to text-figures, all of which are of the same animal and based on an original by Schultze[1]: *Gromia oviformis* Dujardin[2], *Allogromia ovoidea* Rhumbler[3], *Gromia oviformis* Schultze (= *G. ovoidea* Rhumbler)[4], *Allogromia oviforme*[5,6], and *Allogromia oviformis*[7–10]. All except the second in this list, namely, *Allogromia ovoidea* Rhumbler, are incorrect, and as a result of such misdeterminations the belief has arisen that the two animals being discussed are one and the same. Hence *Gromia oviformis* Dujardin, 1835, is now incorrectly recorded in the "Plymouth Marine Fauna"[11] as "*Allogromia oviformis* (Dujardin) [Jepps, 1926, as *Gromia*]".

A short account of the events relevant to this situation partly explains how the confusion has arisen. Dujardin[12] described and figured a new protozoan under the name *Gromia oviformis*. Schultze[1] later described and illustrated a form as *Gromia oviformis* Dujardin, 1835, which was a straightforward misidentification. This view is supported by the fact that in the same publication Schultze describes as new *Gromia dujardinii*, the illustration of which leaves no doubt that it is the same as *Gromia oviformis* Dujardin, 1835. Here then seems to be a case of double misidentification, leaving an animal described and figured but incorrectly identified as *Gromia oviformis*. This situation existed until Rhumbler[13] recognized *Gromia oviformis* Dujardin, 1835, as a form with filose pseudopodia, and *Gromia oviformis* Dujardin of Schultze, 1854 (the misidentified form), as a form with granulo-reticulose pseudopodia. Rhumbler proposed that the filose forms, namely, *Gromia*, be placed in the Class Filosa, and that the granulo-reticulose forms be included in a new genus, *Allogromia*, within the Class Reticulosa. Rhumbler then erected the

new name *Allogromia ovoidea* for that animal misidentified and illustrated by Schultze in 1854.

It was not until 1934, when De Saedeleer[7] discussed Rhumbler's work, that a further change of name was accompanied by any comment, although incorrect names had been used before this date[4,5,8]. De Saedeleer agreed that the *Gromia oviformis* Dujardin of Schultze should be *Allogromia*, but considered, without giving reasons, that a change of the specific name from *oviformis* to *ovoidea* was wrong. He proceeded, therefore, to refer to *Allogromia oviformis*, an unfortunate choice in view of the confusion that has arisen from its usage. According to article 31 of the International Rules of Zoological Nomenclature[14] "a specific name which undoubtedly rests upon an error of identification cannot be retained for the misdetermined species even if the species in question are afterwards placed in different genera". De Saedeleer's claim, therefore, cannot be upheld, and *Allogromia ovoidea* Rhumbler is the correct name for the misidentified *Gromia oviformis* of Schultze, with which the quite different *Gromia oviformis* Dujardin, 1835, is not to be confused.

Quite apart from this account of names, the systematic positions of *Gromia* and *Allogromia* are by no means understood. Sometimes referred to as gromoid forms, they are regarded by some workers as Foraminifera and by others as Testacea. The problem will only be resolved by a fuller understanding of the biology of the animals, of their pseudopodial organization, and of their life-cycles. An extension of the works of Jepps[15] and Arnold[16] to other closely related Testacea and Foraminifera is particularly desirable at this stage in order to give a firmer basis for the distinction between these two groups. At the moment the systematic position depends largely on whether a form produces anastomosing, granular pseudopodia (*Allogromia* and members of the Foraminifera) or pseudopodia which do not, or rarely, anastomose, and are non-granular (*Gromia* and members of the Testacea). Such differences are not always clear cut, and so far there has been no functional interpretation of them. As there are many workers who consider these gromoid animals to be living representatives of a primitive group from which the Foraminifera may have evolved, the answers to these problems should help to clarify the origin of this large and morphologically very diverse order of the Protozoa.

R. H. Hedley

Department of Zoology,
British Museum (Natural History),
London, S.W.7.
Sept. 18.

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Sex Ratio in the Golden Hamster before Uterine Implantation

Most mammalia have a secondary sex ratio near 100 : 100 with a slight excess for the male sex. As male- and female-determining spermatozoa are being produced in equal numbers, the primary sex ratio would also be 100 : 100, provided that the two kinds of sperms are equally able to fertilize. However, a higher mortality-rate in male than in female embryos has been observed in stages in which the sex may be anatomically recognized[1], and is also generally supposed to operate in preceding stages. Based upon this a primary sex-ratio of 150 : 100 has been calculated[1] which must imply a higher frequency of successful fertilizations performed by male- rather than by female-determining spermatozoa.

In order to estimate the sex ratio in as close agreement as possible with the primary one we have determined the sex of a number of embryos before implantation by making use of the morphological differences between the *X*- and *Y*-chromosomes. This was possible in the golden hamster, *Mesocricetus auratus*, as the sex chromosomes, which in this species are larger than the autosomes, may be distinguished from each other[2].

Mated females were killed 80–90 hr. after copulation, at which time the embryos were in the blastocyst stage, containing mostly 20–32 cells. The blastocysts were collected by flushing the uterine horns with Tyrode solution, and treated with a 0·45 per cent saline at 37° C. for 15 min. in order to obtain better spreading of the chromosomes at squashing[3]. The blastocysts were then fixed for some hours in absolute alcohol–acetic acid 3 : 1, stained for 15 min. in acetic-lacmoid solution[4], and mounted as squash preparations in neutral Canada balsam.

Using a Zeiss phase-contrast oil immersion objective (mag. 100 ×, N.A. 1·25) camera lucida drawings were made of the chromosomes of well-spread metaphase plates, and the occurrence of *X*–*X*- and *X*–*Y*-combinations respectively was determined.

As the frequency of metaphase plates was very low—about one plate in every third blastocyst—we introduced a pretreatment of the pregnant females with colchicine[5] in order to increase the number of cells in metaphase at killing. The animals were injected intraperitoneally with 0·025 mgm. colchicine per 100 gm. body-weight 5–8 hr. before being killed. This treatment increased the frequency of metaphases to about one plate per blastocyst, without obscuring the chromosomal morphology.

Until now 51 blastocysts from 39 hamsters have been classified according to sex. Of these, 33 were males and 18 females, giving a sex ratio of 183 : 100, which significantly deviates from 100 : 100 ($t^2 = 4{\cdot}41$, $p < 0{\cdot}05$). The experiments are being continued, and the results from more material will be published in due course.

P. E. Lindahl
G. Sundell

Institute of Zoophysiology,
University of Uppsala.
Sept. 8.

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Australian Discoveries of Emperor Penguin Rookeries in Antarctica during 1954–57

THE emperor penguin (*Aptenodytes forsteri* Gray) breeds only around the coastline of Antarctica. Many decades elapsed between the time when the birds were first seen and the discovery of a breeding place. The first emperor rookery was discovered at Cape Crozier, on Ross Island, in October 1902 [1].

During Sir Douglas Mawson's Australasian Antarctic Expedition, 1911–13, a rookery was discovered at Haswell Islet and another suspected near the Shackleton Ice Shelf[2]. The latter has been confirmed in 1957 by Russian workers operating from Mirny (personal communication). The German Südpolar Expedition saw large numbers of juveniles in December 1902, when beset near the monolith now known as Gaussberg. However, the presence of a rookery here is doubtful, and the chicks may have come from Haswell Islet. Russian workers operating near Gaussberg in 1957 saw no sign of a rookery.

No further discoveries were made until 1948, when a Falkland Islands Dependencies Survey party found a small rookery on the Dion Islets, south of Adelaide Island, Graham Land[3]. In 1950, a larger one was discovered at Pointe Géologie, Terre Adélie, by a French party from Port Martin[4].

Since that time members of the Australian National Antarctic Research Expeditions have discovered five more emperor penguin rookeries. The first of these was found in October 1954 by a two-man sledging party, R. Dovers and G. Schwartz, approximately 50 miles west of the A.N.A.R.E. base Mawson. It is situated on the eastern side of Taylor glacier (67° 28′ S., 60° 53′ E.) and, unlike most emperor rookeries, is not on sea ice but on land. It contains more than five thousand breeding birds and, partly because of its geographical advantages and sheltered position, appears to have a relatively low chick mortality.

In May 1956 during a flight from Mawson westward to King Edward VIII Gulf, Dr. D. A. Dowie and Flight Sergeant J. Seaton, R.A.A.F., saw a smaller rookery, which was visited in the following spring. It is situated on the southern side of Fold Island (67° 20′ S., 59° 23′ E.) and contains nearly two thousand breeding birds. Studies carried out here in 1957 revealed a very high chick mortality.

The other three rookeries were all discovered during 1957. A very large group of birds was seen from the air by Flight Officer D. Johnston, R.A.A.F., in August 1957, 35 miles east of Mawson at approximately 67° 25′ S., 64° 00′ E. It was visited by K. B. Mather, D. Johnston and me on the next day, by aeroplane, and aerial photographs were taken. A fortnight later R. T. Lee and I visited the rookery by 'weasel'. A count made then confirmed the estimate, made from the photographs, of twelve thousand birds. Random sampling of the population revealed that 71 per cent of the birds were holding chicks. Approximately six hundred dead chicks were found lying on the ice, and probably many more had been buried by snow. Evidence of a great many broken and abandoned eggs was also found, and it may be concluded that at least twenty thousand breeding birds entered the rookery during the breeding season.

This rookery is situated on sea ice which is very thick and rough and is made stable by hundreds of grounded bergs in the vicinity. It is unusual in being about eight miles from the nearest group of islands (Douglas Islands) and 7–8 miles from the mainland. The bergs, however, act as islands do at other rookeries, holding the sea ice from breaking out during the breeding season. No land feature is near enough to give it a name, and it is therefore being named Auster rookery, after the plane from which it was first seen. A very large feeding hole was found six miles south of this rookery at the base of a tilted berg[3].

During September 1957 two more rookeries were sighted from the air by Flight Lieutenant P. Clemence, R.A.A.F. Neither has yet been visited. One is situated at Kloa Pt. (66° 37′ S., 57° 11′ E.), near Cape Boothby, 180 miles west of Mawson. Its size was estimated visually as five thousand when it was first sighted; but this has not been confirmed by any other method. It is situated on sea ice which is held in by a small group of islands.

In the same month, during a flight south-west from the A.N.A.R.E. base Davis in the Vestfold Hills, a

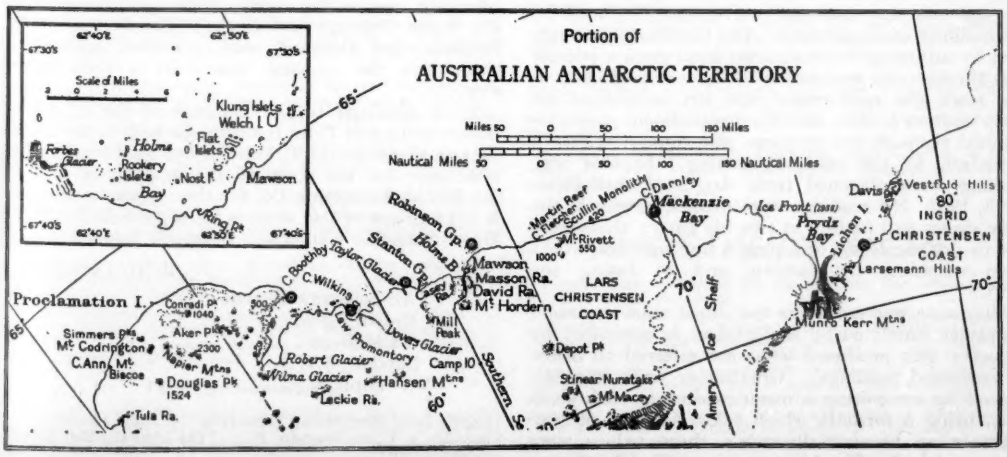

Fig. 1. Part of Australian Antarctic Territory, showing Emperor Penguin rookeries discovered by A.N.A.R.E. From west to east, Kloa Point, Fold Island, Taylor Glacier, Auster Rookery, Cape Darnley, and Amanda Bay

group of birds was seen on the sea ice near a glacier tongue between Davis and the Larsemann Hills (69° 14′ S., 76° 53′ E.). From aerial photographs taken then, the population at that time was estimated to be between one thousand and two thousand birds.

Other parties operating in Antarctica have also reported in personal communications recent discoveries of new emperor penguin rookeries. With the five discovered by A.N.A.R.E. parties it now seems that, although they are by no means numerous, emperor penguin rookeries are no longer a rarity.

Since this communication was drafted, a sixth rookery has been discovered by members of A.N.A.R.E. It is situated in approximately 68° S., 69° 45′ E., among a large group of icebergs on the eastern side of Cape Darnley. It was discovered in August 1958 by Flight Lieutenant H. O. Wilson, R.A.A.F., during a flight from Mawson to Davis. The population is roughly estimated as 5,000.

Richard L. Willing

Antarctic Division,
Department of External Affairs,
Melbourne.
July 7.

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The Tide at Shackleton

The sea tide has been measured at the Trans-Antarctic Expedition's Shackleton Base, on the Filchner Ice Shelf in the Weddell Sea. The ice shelf is afloat over some 500 fathoms of water, and is not thought to be aground anywhere within at least 15 miles; the nearest known land is more than 20 miles to the east. In the absence of any fixed point to which the tide could be referred, a Worden gravimeter was used as an altimeter. The gravimeter was placed in a cavern dug 18 ft. below the snow surface, and photographs automatically taken through the eyepiece every hour. A ten-minute exposure was used so as to average out the continual movement produced by unsteadiness of the ice shelf. The Worden is normally used by adjusting a micrometer head until a pointer seen through the eyepiece is in its zero position; in this work the micrometer was left untouched for many days at a time, and the displacement as photographed through the eyepiece was converted into a correction to the constant setting. In this way readings were obtained from August 8 until October 3, 1957. 145 readings were missed, mostly in the early stages and mainly in two big gaps; these were due to my carelessly dropping a key into the works when reloading the camera, and so fusing the lamp.

Allowance was made for the direct tidal variation of gravity (modified by earth tides) as tabulated by Coguel[1]; this produced what are referred to below as 'corrected readings'. Gravimeter drift was calculated by computing a mean reading at each sixth hour, using a formula which takes account of constituents up to sixth-diurnals; these values were then smoothed. The big gaps were filled by fitting a fifth- or seventh-degree polynomial, and using the curve of residuals. Sub-tabulation was then carried out at hourly intervals. Subtracting the 'corrected readings' from these drift values gave figures proportional to the height of the tide above mean sea-level.

These readings were then divided into two 29-day periods, sharing a common day—first, August 8–September 5, and secondly, September 5–October 3. Each period was then subjected to analysis by the method given in "The Admiralty Tide Tables"[2], with the results set out in Table 1. In the averaging, the first period is somewhat arbitrarily given half the weight of the second, because the readings have more gaps and the gravimeter drift was more erratic in the first period. Gravimeter readings were converted to heights by the usual Bouguer formula with an insignificant modification for the acceleration implied by the rise and fall.

Table 1. Shackleton Base. 77° 59′ S., 37° 10′ W.

	M_2		S_2		N_2	
	H	g	H	g	H	g
Period 1	2·14	157°	1·52	180°	0·32	150°
Period 2	1·98	160°	1·44	174°	0·34	148°
Mean	2·03	159°	1·46	176°	0·33	149

	K_1		O_1		M_4		MS_4	
	H	g	H	g	H	g	H	g
Period 1	1·06	348°	0·75	303°	0·02	179°	0·05	279°
Period 2	0·48	342°	1·02	325°	0·07	131°	0·04	206°
Mean	0·67	345°	0·91	319°	0·05	136°	0·04	235°

Central days: period 1, August 22, 1957; period 2, September 19, 1957. Standard time: 4 hr. west. Heights, H, are given in feet.

It can be seen that the constants derived from the two periods are in poor agreement for the diurnals, that the semi-diurnals are well determined, and that the quarter-diurnals are negligible. It is known that there is a spurious constituent of variable amplitude (of the order of 0·3 ft.) and period 40 hr., coinciding with the interval between visits to the cavern to re-load the camera. This is bigger than was expected; but for just that reason makes it plausible that there should be another spurious constituent large enough to produce serious interference with the diurnals, and of period 24 hr. The constants in Table 1 are tolerably compatible with other measurements in the South Orkneys and Graham Land as given by Roberts and Corkan[3], and are well placed to strengthen the co-tidal charts in a little-known area.

I am indebted to the Director of the Liverpool Observatory and Tidal Institute for help in the analysis, and also to Dr. G. P. Woollard of the University of Wisconsin for the loan of the gravimeter and to the British Petroleum Co. for the automatic camera. A full account of this work is to be published in "The Trans-Antarctic Expedition Scientific Reports".

J. G. D. Pratt

c/o F.I.D. Scientific Bureau,
Crown Agents,
4 Millbank,
London, S.W.1.
Sept. 8.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 17

INSTITUTE OF ACTUARIES (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Mr. E. N. Mutch: "The Progress of Business Computers in Britain". (Further lecture on December 1.)

ROYAL INSTITUTE OF CHEMISTRY (at the Royal Institution, 21 Albemarle Street, London, W.1), at 5.45 p.m.—Dr. David John Manners: "Recent Advances in the Structural Analysis of Polysaccharides".* (Meldola Medal Lecture.)

INSTITUTION OF ELECTRICAL ENGINEERS, LONDON GRADUATE AND STUDENT SECTION (at Savoy Place, London, W.C.2), at 6.30 p.m.—Mr. S. E. Goodall: Presidential Address.

Tuesday, November 18

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. D. A. Sholl: "The Randomness of the Brain".*

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND CONTROL SECTION (in conjunction with the BRITISH NUCLEAR ENERGY CONFERENCE, at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. W. Binns and Mr. W. J. Outram: "Electrification of the U.K.A.E.A. Industrial Group Factories".

PARLIAMENTARY AND SCIENTIFIC COMMITTEE (in Committee Room 12, House of Commons, London, S.W.1), at 5.15 p.m.—Meeting of the General Committee. 5.30 p.m.: Discussion on "Railway Research and Development" initiated by General Sir Brian Robertson, Bt., G.C.B., G.B.E., K.C.M.G., K.C.V.O., D.S.O., M.C.

RESEARCH DEFENCE SOCIETY (in the Lecture Theatre, Zoological Society of London, Regent's Park, London, N.W.1), at 5.30 p.m.—Mr. Richard Fort, M.P.: "The Irrational in Public Life". (Twenty-seventh Stephen Paget Memorial Lecture.)

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. W. Hayes: "Bacterial Genetics and Gene Structure".* (Sixth of eleven lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation. Further lectures on November 20, 25, 27, December 2 and 4.)

PLASTICS INSTITUTE, LONDON AND DISTRICT SECTION (at the Wellcome Building, 183–193 Euston Road, London, N.W.1), at 6.30 p.m.—Mr. A. B. Merriam: "Commercial and Cost Considerations in Injection Moulding". (Junior Lecture.)

Tuesday, November 18—Wednesday, November 19

INSTITUTION OF GAS ENGINEERS (at Church House, Westminster, London, S.W.1), at 9.30 a.m. daily—24th Autumn Research Meeting.

Wednesday, November 19

INSTITUTE OF METAL FINISHING (at the Charing Cross Hotel, Strand, London, W.C.2), at 10.15 a.m.—Symposium on "Technical Control in Electroplating".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 2.30 p.m.—Discussion on "Atmospheric Chemistry".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. L. A. Longden: "Improving the Efficiency of the Mining Industry" (Cadman Memorial Lecture).

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, Portland Place, London, W.1), at 2.30 p.m.—Symposium on "Analytical Instrumentation Developed at Harwell".

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Mr. H. F. Lydall: "The Long-Term Trend in the Size Distribution of Income".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. Redmond: "Television Recording—a Survey of the Problems and the Methods Currently in Use".

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Mr. B. E. Juniper: "Electron Microscopy of Leaf Surfaces".

UNIVERSITY COLLEGE (in the Physiology Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. D. A. Denton (University of Melbourne): "The Control of Secretion of the Transplanted Adrenal Gland".*

INSTITUTION OF MECHANICAL ENGINEERS, APPLIED MECHANICS GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "Working Stresses and Factors of Ignorance".

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (at the Royal Society of Health, 90 Buckingham Palace Road, London, S.W.1), at 6.30 p.m.—Annual General Meeting. Discussion on "Institute Affairs" opened by Dr. C. C. Hall.

Thursday, November 20

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Lord Medway: "Navigation on the Wing in Total Darkness by means of Echo Among Swiftlets of the Genus *Collocalia* in Borneo". 5.5 p.m.—Symposium on "Chromatography and Taxonomy" opened by Dr. E. C. Bate-Smith, Dr. C. A. Wright, Dr. J. B. Harborne, Dr. A. T. R. Mattick and Dr. N. J. Berridge.

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Special General Meeting, Dr. H. Godwin, F.R.S.: "Late-glacial Deposits at Moss Lake, Liverpool"; Dr. H. Godwin, F.R.S., and Mr. E. H. Willis: "Radiocarbon Dating of the Late-glacial Period in Britain" (Studies of the Post-glacial History of British Vegetation, 14).

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Annual General Meeting, followed by Prof. K. A. Hirsch: "Torsion-free Abelian Groups".

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Dr. E. M. Shooter: "The Configuration of Proteins in Solution".* (Further lecture on November 27.)

INSTITUTION OF MINING AND METALLURGY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5.10 p.m.—Scientific Papers.

ROYAL METEOROLOGICAL SOCIETY (in the Conference Hall, County Hall, London, S.E.1), at 5.30 p.m.—Dr. E. T. Pierce: "Thunderstorms". (Popular Lecture for Sixth-form Scholars. To be repeated on November 21.)

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. J. H. Humphrey: "What are γ-Globulins?"* (Seventh of eleven lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation. Further lectures on November 25, 27, December 2 and 4.)

BRITISH GLACIOLOGICAL SOCIETY (at Bedford College Regent's Park, London, N.W.1), at 6 p.m.—Mr. D. W. Humphries: "Kilimanjaro and the International Geophysical Year".

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "What is a Cultured Engineer?"

ROYAL AERONAUTICAL SOCIETY (at the Institution of Mechanical Engineers, Birdcage Walk, London, S.W.1), at 6 p.m.—Second Lanchester Memorial Lecture.

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. I. L. Freeman: "Scientific Investigation of Clay Pits".

INSTITUTION OF ELECTRONICS (in the Assembly Hall of the University of London Institute of Education, Malet Street, London, W.C.1), at 7 p.m.—Mr. E. Wolfendale: "The Applications of Transistors in Communications and Control Equipment".

OIL AND COLOUR CHEMISTS' ASSOCIATION, LONDON SECTION (at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1), at 7 p.m.—Mr. E. F. Redknap: "Reactions of Drying Oils with Hydrocarbons".

PHARMACEUTICAL SOCIETY OF GREAT BRITAIN (at 17 Bloomsbury Square, London, W.C.1), at 7.30 p.m.—Scientific Meeting on "Applications of Gas Chromatography to Pharmaceutical Analyses".

Friday, November 21

BRITISH PSYCHOLOGICAL SOCIETY, OCCUPATIONAL PSYCHOLOGY SECTION (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mr. T. Lupton: "Problems of Participant Observation".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5.15 p.m.—Mr. George Lowe: "Navigating Across the Antarctic".

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Prof. L. L. Beranek: "The Transmission of Acoustic Waves Through Structures" (Thomas Hawksley Lecture).

ANTIQUARIAN HOROLOGICAL SOCIETY (at the Science Museum, South Kensington, London, S.W.7), at 7 p.m.—Mr. H. Alan Lloyd: "The Baldewein Astronomical Clock of 1562".

ROYAL INSTITUTE OF CHEMISTRY (joint meeting with the EAST ANGLIA SECTION and CAMBRIDGE UNIVERSITY CHEMICAL SOCIETY, at the University Chemical Laboratory, Lensfield Road, Cambridge), at 8.30 p.m.—Dr. E. C. Barton-Wright: "The Chemistry of Wines and Spirits".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. F. C. Fraser: "Some Aquatic Adaptations of Whales and Dolphins".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

RESEARCH ASSISTANT, for work on adsorption of polar vapours on ionic crystals—Dr. F. C. Tomkins, Chemistry Department, Imperial College of Science and Technology, London, S.W.7 (November 19).

CHIEF (with a recognized university degree or equivalent in agricultural science and/or science (with physiology as a major subject) and/or veterinary science, and at least ten years postgraduate experience of research work and actively engaged in research in animal physiology, animal nutrition, animal husbandry, or allied subjects) OF THE ANIMAL PRODUCTION DIVISION—The Director, An Foras Talúntais (Agricultural Institute), 21 Earlsfort Terrace, Dublin (November 21).

LECTURER (able to teach organic chemistry to graduate level, conduct research, and preferably with industrial experience and the

ability to direct work of postgraduate research students) IN ORGANIC CHEMISTRY in the Department of Chemistry and Biology, College of Technology, Liverpool—The Director of Education, City of Liverpool Education Committee, 14 Sir Thomas Street, Liverpool 1 (November 21).

SCIENTIFIC AIDE, Senior Research Officer grade (with a recognized university degree in agricultural science, at least five years post-graduate research experience in some branch of agricultural science, and preferably a competent knowledge of the organization of agricultural research and experimental work and the conduct of seminars or study courses)—The Director, An Foras Talúntais (Agricultural Institute), 21 Earlsfort Terrace, Dublin (November 21).

ASSISTANT, Grade B (preferably specializing in inorganic chemistry and also some applied science subjects), at Northampton College of Technology, TO TEACH CHEMISTRY up to Higher National Certificate and General B.Sc. standard—The Chief Education Officer, Borough Education Office, "Springfield", Cliftonville, Northampton (November 22).

LECTURER (with up-to-date industrial and/or research experience) IN INORGANIC CHEMISTRY—The Principal, Nottingham and District Technical College, Burton Street, Nottingham (November 22).

TECHNICIAN (preferably with an interest in complex physical apparatus) IN THE RADIOISOTOPES LABORATORY, Pollards Wood Research Station, Chalfont St. Giles, Bucks, to help with investigations on protein and nucleic acid biosynthesis—The Secretary, Chester Beatty Research Institute, Fulham Road, London, S.W.3, quoting "Isotopes" (November 22).

PRINCIPAL SCIENTIFIC OFFICER (with a first- or second-class honours degree in physics, physical chemistry or biochemistry, and at least three years postgraduate or other approved experience) at the Ministry of Agriculture, Fisheries and Food, London, for work on nuclear problems in relation to agriculture and food—The Civil Service Commission, 30 Old Burlington Street, London, W.1, quoting S.4900/58 (November 27).

CHAIR OF METALLURGY—The Registrar, The University, Manchester 13 (December 8).

GULBENKIAN RESEARCH FELLOW to investigate certain aspects of the teaching of physics or chemistry in schools—The Registrar and Secretary, The University, Bristol (December 15).

LECTURER or ASSISTANT LECTURER IN MATHEMATICS at the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (December 15).

LECTURER or SENIOR LECTURER IN ANIMAL NUTRITION at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (December 15).

READER IN NUCLEAR ENGINEERING at Queen Mary College, Mile End Road, London, E.1—The Academic Registrar, University of London, Senate House, London, W.C.1 (December 16).

SENIOR LECTURER IN MATHEMATICS at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 16).

ECOLOGIST (man, with a first- or second-class honours degree, and preferably with some knowledge of statistics), to join a team studying marine plankton, using continuous plankton recorders—The Officer-in-Charge, Oceanographic Laboratory, 78 Craighall Road, Edinburgh 6 (December 20).

LECTURER and an ASSISTANT LECTURER IN GENETICS—The Secretary of University Court, The University, Glasgow (December 31).

LECTURER IN VETERINARY PATHOLOGY AND BACTERIOLOGY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 31).

LECTURER (with a degree in engineering, preferably with honours, and experience and interest in the field of thermodynamics and heat engines) IN MECHANICAL ENGINEERING at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 31).

PROFESSOR OF PHARMACOLOGY—The Registrar, University Registry, Oxford (December 31).

DRUMMOND FELLOW (Senior or Junior, depending on qualifications) for Research in Nutrition—The Honorary Secretary, Drummond Trust, University College, Gower Street, London, W.C.1 (January 31).

ASSISTANT, Grade B (preferably with the ability to teach horticulture), TO TEACH BOTANY to B.Sc. (General) and G.C.E. Advanced and Ordinary levels—The Clerk to the Governors, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham, Essex.

BIOCHEMIST, Basic grade (preferably with experience in routine medical biochemistry)—The Group Pathologist, Mental Hospitals' Group Laboratory, West Park Hospital, Epsom, Surrey.

BIOCHEMIST (with B.Sc. or M.Sc.), for research on insulin antagonisms in blood plasma—Dr. Vallance-Owen, Department of Medicine, University of Durham, King's College, Newcastle-upon-Tyne.

CHEMIST or BIOCHEMIST (preferably with a knowledge of carbohydrate chemistry) IN THE PHYSICAL CHEMISTRY DEPARTMENT, for research in immunological problems covering a wide range of interest—The Secretary, Animal Diseases Research Association, Moredun Institute, Gilmerton, Edinburgh 9.

RESEARCH ASSISTANT (with a good degree in either mathematics, physics or electrical engineering) IN THE SUB-DEPARTMENT OF COMPUTATION for work concerned with programming logical problems for a Pegasus computer—The Secretary and Registrar, The University, Highfield, Southampton.

SENIOR LECTURER (with good academic qualifications and suitable experience in the teaching of a branch of advanced mathematics) IN MATHEMATICS—The Secretary and Clerk to the Governors, Borough Polytechnic, London, S.E.1.

SENIOR SOIL CONSERVATION OFFICER (with a university degree or a recognized diploma in agriculture, and not less than ten years' experience in soil conservation work, preferably in East Africa) in Barbados to undertake the direction of conservation work—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD 63/28/06.

ZOOLOGIST (with a good honours degree in zoology and competent to plan zoological subjects for either television or film production), to carry out production and research work in conjunction with the Television and Film Unit located at the London Zoo, Regent's Park—The Secretary, Zoological Society of London, Regent's Park, London, N.W.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

British Medical Bulletin, Vol. 14, No. 3 (September, 1958): Symposium on Metabolism of Lipids. Pp. 197–278+1 plate. (London: British Council, 1958.) 20*s.* [129

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 987, Vol. 251 (4 September, 1958): The Internal Flow Problem in Axi-Symmetric Supersonic Flow. By J. J. Mahony. Pp. 1–21. 7*s.* Series B: Biological Sciences. No. 683, Vol. 241 (4 September, 1958): The Ecology of Lagos Lagoon. 1: The Lagoons of the Guinea Coast. By J. E. Webb. 2: The Topography and Physical Features of Lagos Harbour and Lagos Lagoon. By M. B. Hill and J. E. Webb. 3: The Life History of *Branchiostoma nigeriense* Webb. By J. E. Webb. 4: On the Reactions of *Branchiostoma nigeriense* Webb to Its Environment. By J. E. Webb and M. B. Hill. 5: Some Physical Properties of Lagoon Deposits. By J. E. Webb. Pp. 307–419+plates 11–17. 47*s.* No. 684, Vol. 241 (4 September, 1958): On the Basic Form and Adaptations to Habitat in the Lucinacea (Eulamellibranchia). By J. A. Allen. Pp. 421–484+plate 18. 21*s.* 6*d.* (London: Royal Society, 1958.) [129

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 20: The Rearing of Chickens. Pp. 15. (Belfast: Ministry of Agriculture, 1958.) [169

City of Leeds. Annual Report of the Sub-Libraries and Arts (Museums) Committee to the Council for the year ended 31st March, 1958. Pp. 12. (Leeds: Leeds City Museums, 1958.) [189

Proceedings of the Royal Irish Academy. Vol. 59, Section B, No. 7: The Dolerite Plug at Tievebulliagh, near Cushendall, Co. Antrim. By S. O. Agrell and J. M. Langley. Pp. 93–127+plate 3. 4*s.* 6*d.* Vol. 59, Section B, No. 8: The Food and Growth of Brown Trout (*Salmo trutta* L.) in Three Rivers in Co. Tyrone. By Noelle E. Stinson. Pp. 129–154. 3*s.* 6*d.* Vol. 59, Section B, No. 9: The Cashel-Lough Wheelaun Intrusion, Co. Galway. By Bernard E. Leake. Pp. 155–204+plate 4. 7*s.* Vol. 59, Section B, No. 10: Salmon Movements Around Ireland—8: From Drift Nets Along the Coast of County Donegal (1953–1957). By Arthur E. J. Went. Pp. 205–212. 1*s.* Vol. 59, Section B, No. 11: A Survey of Irish Formicidae. By C. A. Collingwood. Pp. 213–219. 1*s.* (Dublin: Hodges, Figgis and Co., Ltd., 1958.) [189

Other Countries

Proceedings of the California Academy of Sciences. Fourth Series. Vol. 29, No. 6: *Bathycalanus sverdrupi*, N. SP., a Copepod Crustacean from Great Depths in the Pacific Ocean. By Martin W. Johnson. Pp. 257–265. Vol. 29, No. 7: The Distribution of Wood-Boring *Limnoria* in California. By Robert J. Menzies. Pp. 267–272. Vol. 29, No. 8: A New Fish, *Chaetodon falcifer*, from Guadalupe Island, Baja California, with notes on Related Species. By Carl L. Hubbs and Andreas B. Rechnitzer. Pp. 273–313+3 plates. (San Francisco, Calif.: California Academy of Sciences, 1958.) [169

United States Department of the Interior: Geological Survey. Bulletin 1042-M: Optical Calcite Deposits in Park and Sweet Grass Counties, Montana. By W. C. Stoll and Frank C. Armstrong. Pp. iv+431–479+plates 23–41. n.p. Bulletin 1057: Geology of the Manganese Deposits of Cuba. By Frank S. Simmons and John A. Straczek. Pp. xi+289+32 plates. n.p. Bulletin 1066-E: Index to Geophysical Abstracts 168–171, 1957. Pp. ii+381–456. 30 cents. Bulletin 1072-A: Records of Unsuccessful Test Wells Drilled for Oil and Gas in Mississippi as of July 1, 1956. By Helen M. Beikman and Sophie Drakoulis. Pp. iii+66. 30 cents. Bulletin 1086-A: Geophysical Abstracts 172 January–March, 1958. By Mary C. Rabbitt, Dorothy B. Vitaliano, S. T. Vesselowsky and others. Pp. iii+83. 35 cents. Professional Paper 308: Geology and Ore Deposits of the Jermone Area, Yavapai County, Arizona. By C. A. Anderson and S. C. Creasey. Pp. vi+185+13 plates. n.p. (Washington, D.C.: Government Printing Office, 1958.) [169

Union of South Africa. Department of Commerce and Industries: Division of Fisheries. Investigational Report No. 31: The South African Pilchard (*Sardinops ocellata*) and Maasbanker (*Trachurus trachurus*). The Predation of Sea-birds in the Commercial Fishery. By Dr. D. H. Davies. (Reprint from *Commerce and Industry*, June 1958.) (Pretoria: Government Printer, 1958.) [189

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